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Technology and Equipment

Stockholm, Sweden, 10-14 June 1985

CONDITIONS OF ENTRY INTO THE CAPITAL GOODS SECTOR AND INTEGRATED MANUFACTURE*

Background document to Issue I

Prepared by the UNIDO secretariat

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CHAPTER 1
INTRODUCTION

1.1 Background

1. The First Consultation on the Capital Goods Industry which was held at Brussels, Belgium, from 21 to 25 September 1981[1/], drew attention to a fundamental disequilibrium between the developed and developing countries' production of capital goods[2/].

2. Furthermore, the Consultation recognized that approximately 74% of the developing countries' production of capital goods was concentrated in six or seven Newly Industrializing Countries (NICs). This situation indicated another structural problem: there were imbalances among the developing countries themselves.

3. The First Consultation has, therefore, recommended that UNIDO should, among others:

- Carry out studies to identify the barriers hindering the entry of developing countries into the capital goods sector and to formulate possible strategies to remove these constraints; and
- Assist those developing countries which aim at entering into and/or developing their capital goods industries.

4. Other related UNIDO studies and discussions at the meetings on the agricultural machinery industry[3,4,5/] have identified yet another structural

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1/ UNIDO; Report of the First Consultation on the Capital Goods Industry, ID/276 (ID/WG.342/8/Rev.1), 1981.

2/ In 1980, the shares of developed and developing countries in the total world manufacturing value added in capital goods of US$ 760 billion (constant 1975 dollars) were 94.7 and 5.3 %,respectively - UNIDO; The second world-wide study on capital goods: The sector in figures, UNIDO/IS.505, 1984.

3/ UNIDO; Report of the First Regional Consultation on the Agricultural Machinery Industry, ID/285, 1982.

4/ UNIDO; Report of the Workshop on Design and Development of Agricultural Equipment in Africa, UNIDO/PC.85, 1983.

5/ UNIDO; Agricultural Machinery and Rural Equipment in Africa; A new Approach to a Growing Crisis, UNIDO/IS.377, 1983.

imbalance with regard to the geographical distribution of capital goods industry within the individual developing countries. It was observed that in most developing countries, the capital goods industry, if existant, has been concentrated in and around urban centres. The correction of this imbalance which brought along additional social problems, would require implementation of rural development programmes.

1.2 Scope of the work

5. This study aims at:

a) Developing a methodological framework which is based on systems theory and could be used for the analysis of capital goods industry;

b) Discussing the relevant issues of classification of capital goods and typology of developing countries, and integrated planning within the framework of methodology described in (a);

c) Identifying the barriers to entry into the capital goods sector in those developing countries which have no or only embryonic capital goods industry;

d) Identifying the possible policies and strategies to remove these barriers and, among others, identifying a possible techno-economical route for entry into the capital goods sector, i.e., the multipurpose production approach.

1.3 Presentation

6. This report is presented in three main parts:

a) Part I: Development of a methodology for the analysis of capital goods industry in the developing countries:

- A systems approach to describe the establishment, operation and development of the capital goods industry;
- A classification of capital goods by using the Analysis of Technological Complexity (ATC) method, and according to the conditions of their manufacture;
- A typology of developing countries according to their potential to enter into and/or develop the capital goods industry;

- An integrated planning technique utilizing ATC methodology for the capital goods industry development.

b) Part II: Identification of barriers to the entry of developing countries into the capital goods sector and discussion of policies aimed at removing these barriers with special emphasis on the:

- Selection of capital goods according to typological characteristics of different groups of countries;
- Identification of constraints by taking both the conditions of manufacture of selected capital goods and socio-economic and technical infrastructure of the country groups into account;
- Selection of manufacturing routes with special emphasis on the application of multipurpose production approach;
- Formulation of strategies aimed at removing barriers along the selected route for manufacture.

c) Part III: Multipurpose production approach and its application to the capital goods industries of developing countries.

- Identification of precise rules of establishing multipurpose production units (MPUs);
- Discussion on the multipurpose production of agricultural machinery and other rural equipment.

CHAPTER 2

A SYSTEMS APPROACH TO THE CAPITAL GOODS INDUSTRY

2.1 Introduction

7. Due to its wide coverage and complexity, it is difficult to formulate an empirical identification of the capital goods industry to analyze the diversified range of technological and economic issues. Nevertheless, there are several analytical approaches. The methodology common to all these approaches consists of dividing the sector into two distinct categories as capital (or investment) goods and consumer durable goods industries and then testing the "capital-goodness" either by checking the forward and/or backward linkages [6,7,8,9] or by estimating the mean time taken to consume the final product[10]. Although useful as macroeconomic tools, these models do not always provide an insight to the linkages between the macroeconomic planning/decision-making and microeconomic implementation.

8. The systems approach adopted here has been designed primarily to find answers to two important questions, namely, "What to produce?" and "How to produce?", often asked by developing countries either entering into the sector or wishing to improve their production capabilities.

2.2 World capital goods industry system

9. A simplified dynamic, non-linear feedback system representing the world

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6/ Hirschmann, A.C., The strategy of economic development, Yale University Press, New Haven, 1958.

7/ Rasmussen, N.P., Studies in inter-sectoral relations, North Holland Publishing Company, Amsterdam, 1952.

8/ Chenery, H.B. and Clarke, P.G., Interindustry economics, John Wiley and Sons, New York, 1959.

9/ Simpson, D. and Tsukui, J., The fundamental structure of input-output tables: An international comparison, Review of Economics and Statistics, v.47, p.434-446, 1965.

10/ Chng, M.K., The empirical identification of a capital goods sector, Oxford Bulletin of Economics and Statistics, v.43, p.207-223, 1981.

capital goods industry is shown in Figure 2.1 [11,12]

10. As any other similarly classified system, the capital goods industry system has five interrelated structural and operational elements: (1) Input; (2) processor; (3) output; (4) feedback, and (5) control. Input is the start-up component on which the system operates. Output, the purpose or objective for which the system was designed, is the result of operation. Processor is the activity that makes the transformation of input into output possible. Control and feedback are the system elements which take the necessary measures for smooth operation of the system (i.e., remaining in equilibrium for a given output).

11. All direct inputs shown in Figure 2.1, i.e., materials, technical services, energy, labour, finance and infrastructure are outputs of other systems. For example, iron and steel products, which are material inputs to the capital goods industry, are outputs of the iron and steel industry. On the other hand, iron and steel industry requires capital goods as one of its inputs. Therefore, the backward and forward linkages of the capital goods industry are established through its inputs and outputs, respectively.

2.3 National capital goods industry system

12. The systems representation of a national capital goods industry is given in Figure 2.2. A national system has many shortcomings compared to a balanced global system. Particularly in developing countries, the establishment, start-up and operation of the system may take place in an imperfect environment. The lack and/or interrupted supply of some inputs such as inadequate level of indigeneous technology, limited skilled labour supply, lack of external and/or internal financing of hardware and software activities, underdeveloped infrastructure, etc. are some of the barriers hindering the development of a capital goods industry in a developing countries.

11/ Lerner, A. Ya.; Fundamentals of cybernetics, Chapman and Hall, London, 1972.

12/ D'Azzo, J.J. and Houpis, C.H.; Feedback control system analysis and synthesis, McGraw-Hill Book Company, New York, 1966.

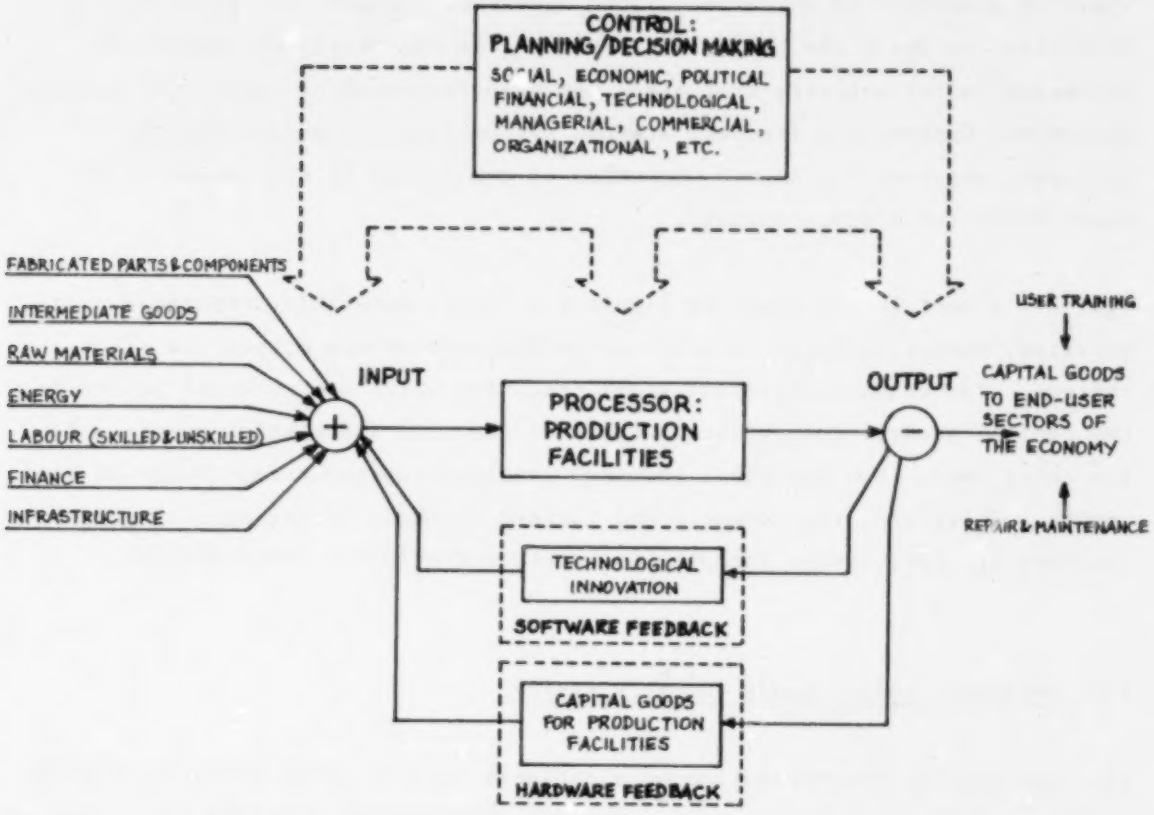

Figure 2.1 World capital goods industry system

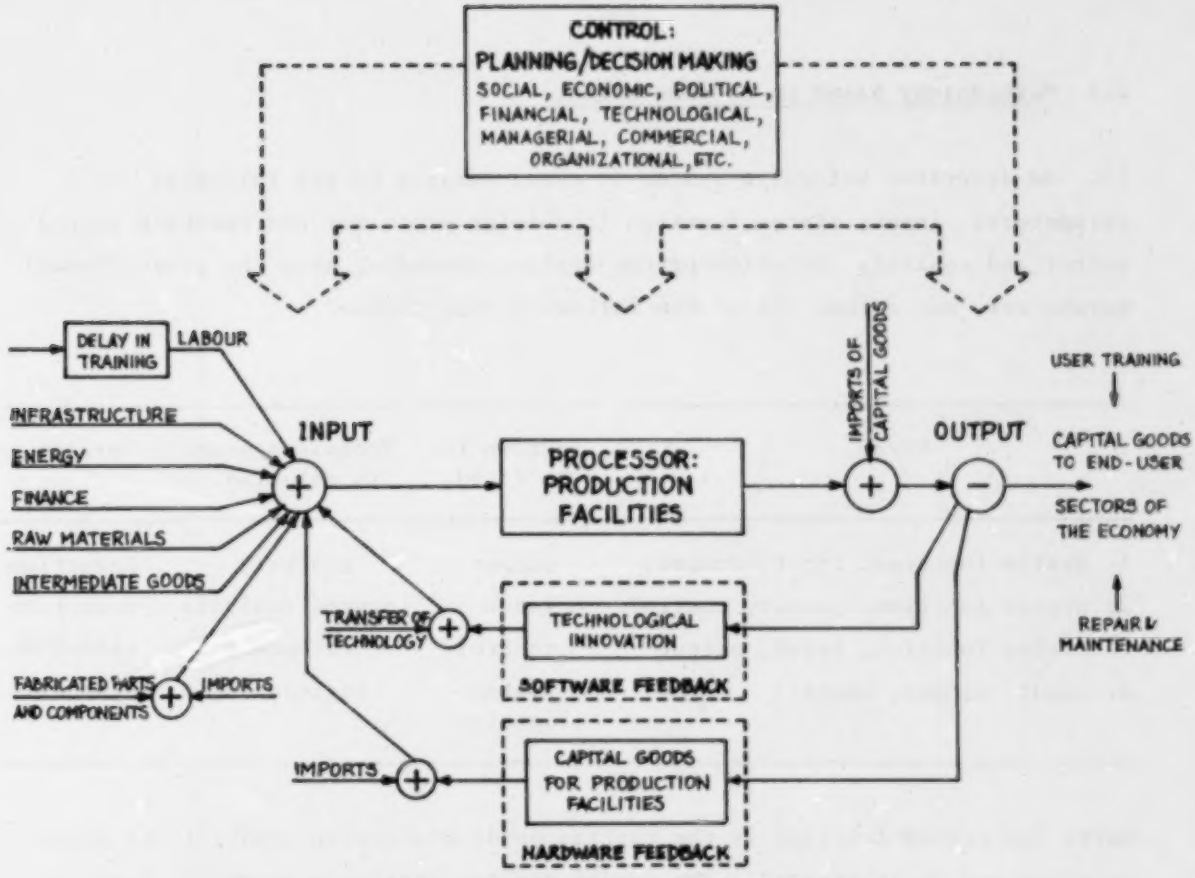

Figure 2.2 System representation of a national capital goods industry.

Consequently, the task laying ahead of developing countries wishing to develop their capital goods industries is huge and complicated. It is therefore imperative that the decision-makers at national level take every precaution to minimize expensive mistakes.

2.4 Methodology based on systems science

13. As described before, a system is characterized by the following parameters: input, system function (combining processor and feedback loops), output and control. Solution of the system, depending upon the given (known) parameters, may assume one of the following four forms:

Given	Unknown to be found	Technique used in solution	Operation
1. System function, input, control	output	analysis	deduction
2. System function, output, control	input	inverse analysis	deduction
3. System function, input, output	control	science	induction
4. Input, output, control	system function	engineering	synthesis

Here, the system function is the capital goods production capabilities (both existing and to be created); the inputs are the available resources (natural, human, physical, etc.); the output is the total demand for capital goods; and control is the implementation of policies and strategies formulated according to the social, economic, political, etc. objectives of the country.

14. It is clear that the solution method will be different for developed and developing countries. In a developed country with an established system, empirical solutions may be possible. A developing country, on the other hand, may have either a partly operational system or no system at all. Therefore, an iterative planning technique is required to estimate the possible values that variable parameters may assume over a specified time period. Figure 2.3 shows the general outline and flowchart of such a technique.

15. As it can be seen from the flow-chart presented in Figure 2.3, the overall task is a system design exercise which implies the use of almost all system solution techniques at one stage or the other before reaching the final implementation phase. At each stage (for example, estimation of output, fitting a system function, calculation of inputs, etc.), there is an absolute need for reliable information . Therefore, the collection of extensive and reliable data at national and international levels is a prerequisite and should be given the highest priority.

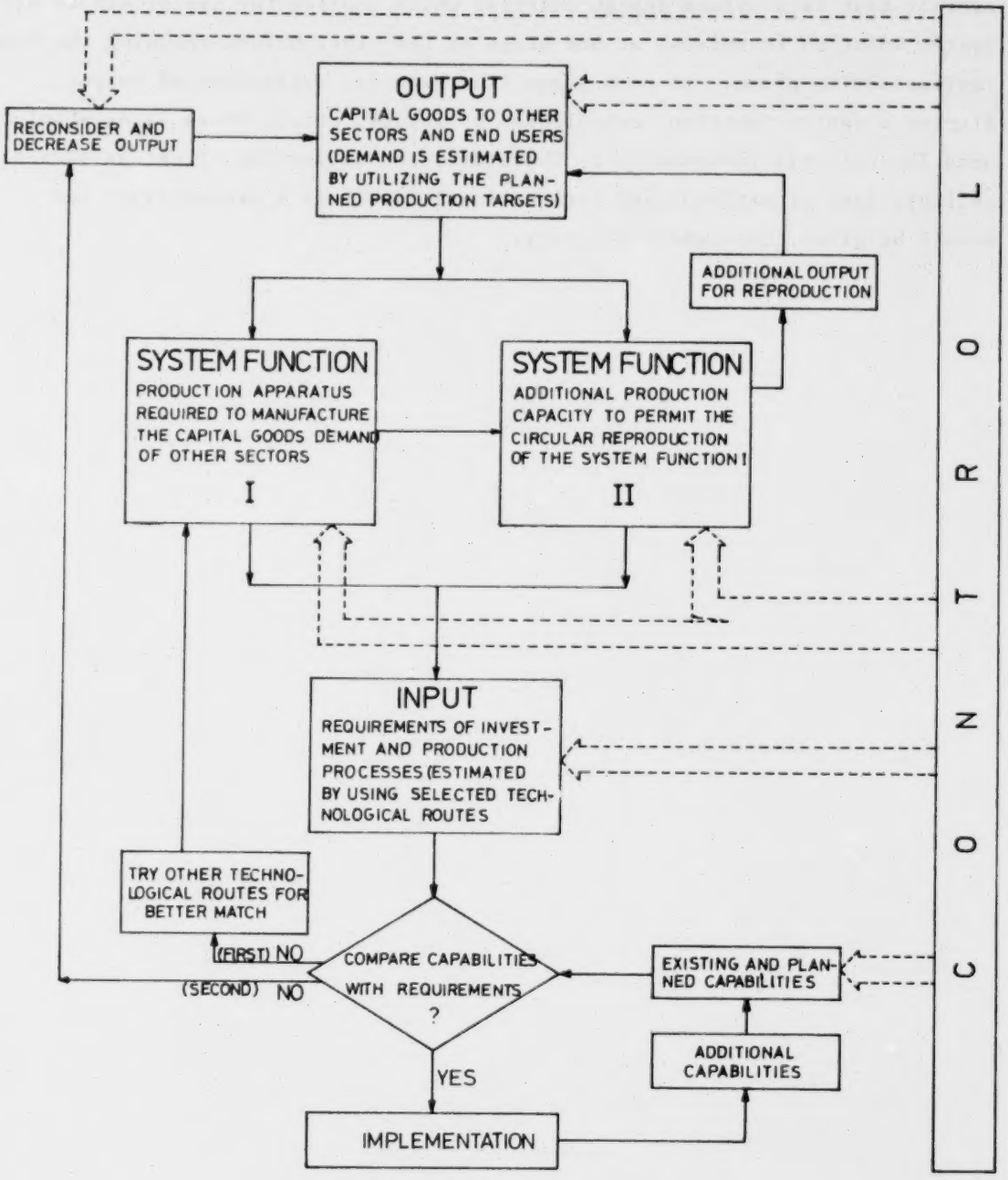
OUTPUT
CAPITAL GOODS TO OTHER SECTORS AND END USERS (DEMAND IS ESTIMATED BY UTILIZING THE PLANNED PRODUCTION TARGETS)
RECONSIDER AND DECREASE OUTPUT
ADDITIONAL OUTPUT FOR REPRODUCTION
SYSTEM FUNCTION
PRODUCTION APPARATUS REQUIRED TO MANUFACTURE THE CAPITAL GOODS DEMAND OF OTHER SECTORS
I
SYSTEM FUNCTION
ADDITIONAL PRODUCTION CAPACITY TO PERMIT THE CIRCULAR REPRODUCTION OF THE SYSTEM FUNCTION I
II
INPUT
REQUIREMENTS OF INVESTMENT AND PRODUCTION PROCESSES (ESTIMATED BY USING SELECTED TECHNOLOGICAL ROUTES
TRY OTHER TECHNOLOGICAL ROUTES FOR BETTER MATCH
(FIRST) NO
(SECOND) NO
COMPARE CAPABILITIES WITH REQUIREMENTS ?
EXISTING AND PLANNED CAPABILITIES
ADDITIONAL CAPABILITIES
YES
IMPLEMENTATION
CONTROL

Figure 2.3 System design exercise for capital goods industry of a developing country.

CHAPTER 3

A CLASSIFICATION OF CAPITAL GOODS ACCORDING TO THEIR CONDITIONS OF MANUFACTURE AND TECHNOLOGICAL ROUTE

3.1 Technological production routes

16. In Chapter 2, the identification of the capital goods industry system was discussed. It is now intended to develop a classification of capital goods and to study the conditions of their manufacture from industrial and technological points of view.

17. The very wide spectrum of capital goods is not only due to the type and nature of the machines but also due to the manufacturing processes, components, know-how, etc. required for their production. A systematic analysis of technological production routes is necessary to unravel the confusion created by the wide variety of products and processes and to furnish developing countries with precise elements facilitating their choice of products and manufacturing technologies.

18. A production route is defined as a chain of successive technological activities throughout the entire input-output process of the manufacture of a capital good. These technological activities, which take part in an environment specified by the economic and social infrastructure, comprise not only the manufacture, per se, of the product, but also organizational aspects, knowledge, etc. Figure 3.1 gives a schematic description of the technological production route.

19. The concept of technological production route and its application to specific cases (e.g., machine tools, agricultural machinery, electric power equipment, etc.) can help to apprehend the complicated nature of an industrial production by analyzing the sequence, nature and importance of the functions performed by the various operators.

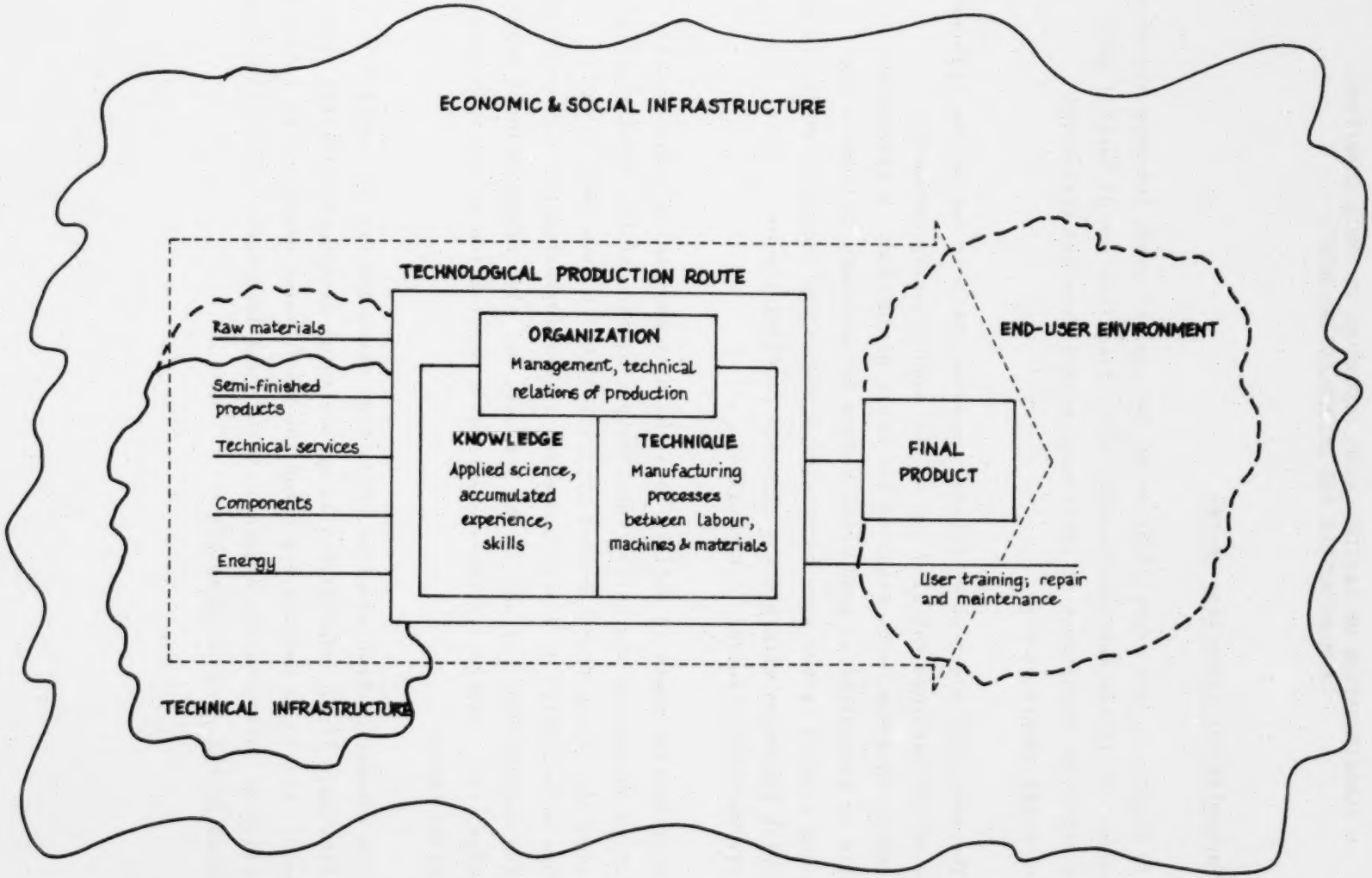

Figure 3.1 Schematic description of the technological production route.

3.2 Analysis of technological complexity (ATC)

20. Analysis of technological production routes requires analytical tools. In order to answer the questions "What to produce?" and "How to produce?", an analysis of complexity with regard to product design, product components and manufacturing processes has to be carried-out. One approach is to utilize a method which facilitates the quantitative measurement of the complexity of manufacture of a product when the production route is given. Since 1979, UNIDO has been developing such a method.

21. There are several UNIDO publications on the ATC method[13,14,15,16/]. Here, only a brief description is given. Figure 3.2 shows the groups of a total 103 factors which are taken into consideration in the ATC. These factors are grouped in 3 blocks which, in turn, divided into the following sub-blocks:

a) **Block A: Central unit of production:**

- Sub-block A1: General factors of product and production unit;
- Sub-block A2: Know-how factors;
- Sub-block A3: Production factors.

b) **Block B: Technical infrastructure:**

- Sub-block B1: Factors of semi-finished products;
- Sub-block B2: Factors of specialized technical services from the third parties.

c) **Block C: Components.**

22. Each factor is characterized by six possible levels of complexity[17/]

13/ UNIDO; Technology in the service of development, ID/WG.324/4 and Add.1, 1980.

14/ UNIDO; First global study on the capital goods industry: Strategies for development, ID/WG.342/3, 1981.

15/ Vidossich, F. (UNIDO Consultant); The index of complexity of capital goods: User Manual, 1982.

16/ Vidossich, F. (UNIDO Consultant); Human resources and technological complexity of capital goods, 1982.

17/ The detailed description of parameters according to six complexity levels is available upon request from the UNIDO Secretariat.

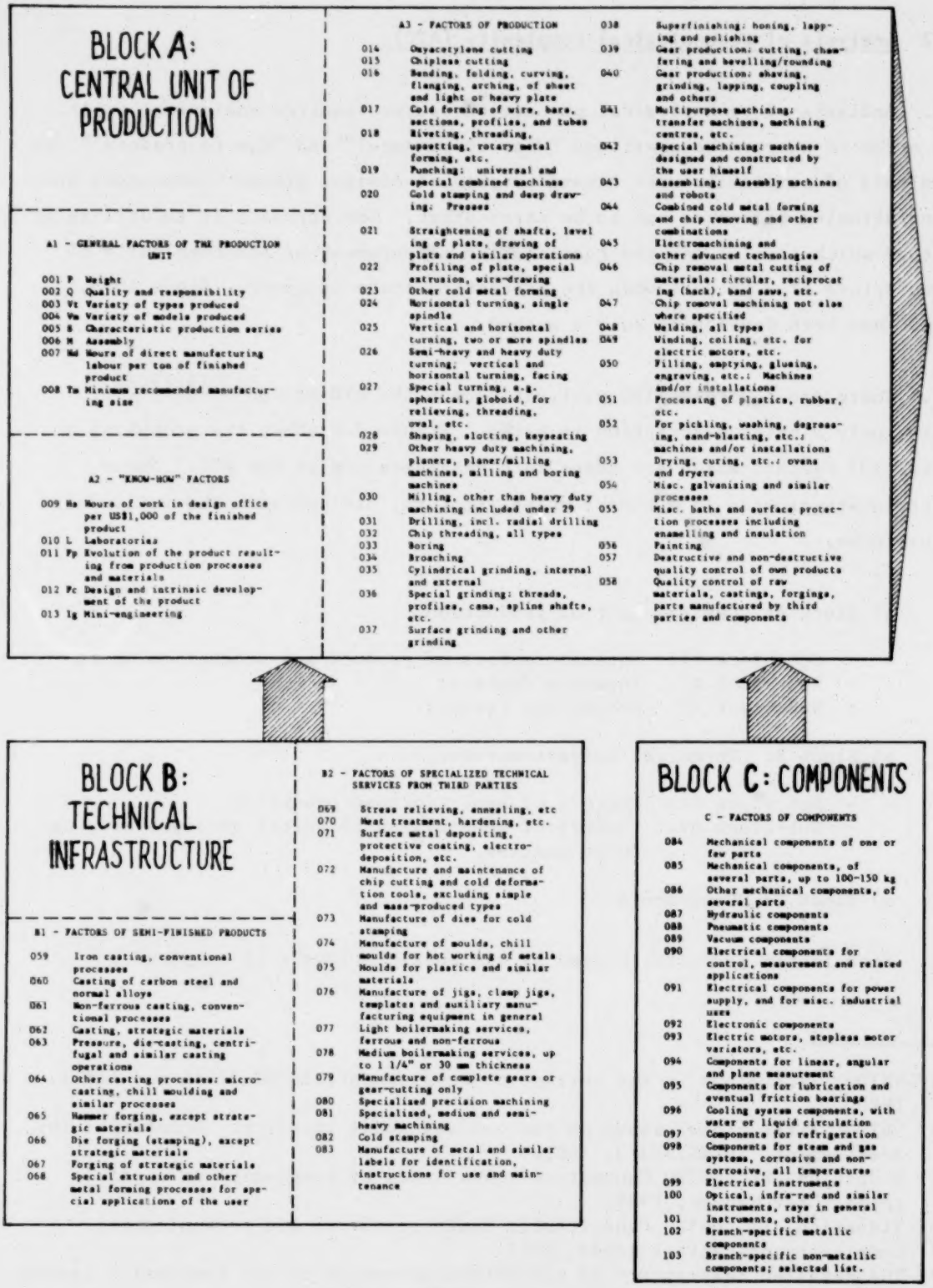
BLOCK A: CENTRAL UNIT OF PRODUCTION
A1 - GENERAL FACTORS OF THE PRODUCTION UNIT
001 P Weight
002 Q Quality and responsibility
003 Vt Variety of types produced
004 Vm Variety of models produced
005 S Characteristic production series
006 M Assembly
007 Hd Hours of direct manufacturing labour per ton of finished product
008 Tm Minimum recommended manufacturing size
A2 - "KNOW-HOW" FACTORS
009 Hs Hours of work in design office per US$1,000 of the finished product
010 L Laboratories
011 Fp Evolution of the product resulting from production processes and materials
012 Pc Design and intrinsic development of the product
013 Ig Mini-engineering
A3 - FACTORS OF PRODUCTION
014 Oxyacetylene cutting
015 Chipless cutting
016 Bending, folding, curving, flanging, arching, of sheet and light or heavy plate
017 Cold forming of wire, bars, sections, profiles, and tubes
018 Riveting, threading, upsetting, rotary metal forming, etc.
019 Punching: universal and special combined machines
020 Cold stamping and deep drawing: Presses
021 Straightening of shafts, leveling of plate, drawing of plate and similar operations
022 Profiling of plate, special extrusion, wire-drawing
023 Other cold metal forming
024 Horizontal turning, single spindle
025 Vertical and horizontal turning, two or more spindles
026 Semi-heavy and heavy duty turning; vertical and horizontal turning, facing
027 Special turning, e.g. spherical, globoid, for relieving, threading, oval, etc.
028 Shaping, slotting, keyseating
029 Other heavy duty machining, planers, planer/milling machines, milling and boring machines
030 Milling, other than heavy duty machining included under 29
031 Drilling, incl. radial drilling
032 Chip threading, all types
033 Boring
034 Broaching
035 Cylindrical grinding, internal and external
036 Special grinding: threads, profiles, cams, spline shafts, etc.
037 Surface grinding and other grinding
038 Superfinishing: honing, lapping and polishing
039 Gear production: cutting, chamfering and bevelling/rounding
040 Gear production: shaving, grinding, lapping, coupling and others
041 Multipurpose machining: transfer machines, machining centres, etc.
042 Special machining: machines designed and constructed by the user himself
043 Assembling: Assembly machines and robots
044 Combined cold metal forming and chip removing and other combinations
045 Electromachining and other advanced technologies
046 Chip removal metal cutting of materials: circular, reciprocating (hack), band saws, etc.
047 Chip removal machining not elsewhere specified
048 Welding, all types
049 Winding, coiling, etc. for electric motors, etc.
050 Filling, emptying, glueing, engraving, etc.: Machines and/or installations
051 Processing of plastics, rubber, etc.
052 For pickling, washing, degreasing, sand-blasting, etc.: machines and/or installations
053 Drying, curing, etc.: ovens and dryers
054 Misc. galvanizing and similar processes
055 Misc. baths and surface protection processes including enamelling and insulation
056 Painting
057 Destructive and non-destructive quality control of own products
058 Quality control of raw materials, castings, forgings, parts manufactured by third parties and components
FINISHED CAPITAL GOOD
BLOCK B: TECHNICAL INFRASTRUCTURE
B1 - FACTORS OF SEMI-FINISHED PRODUCTS
059 Iron casting, conventional processes
060 Casting of carbon steel and normal alloys
061 Non-ferrous casting, conventional processes
062 Casting, strategic materials
063 Pressure, die-casting, centrifugal and similar casting operations
064 Other casting processes: microcasting, chill moulding and similar processes
065 Hammer forging, except strategic materials
066 Die forging (stamping), except strategic materials
067 Forging of strategic materials
068 Special extrusion and other metal forming processes for special applications of the user
B2 - FACTORS OF SPECIALIZED TECHNICAL SERVICES FROM THIRD PARTIES
069 Stress relieving, annealing, etc
070 Heat treatment, hardening, etc.
071 Surface metal depositing, protective coating, electrodeposition, etc.
072 Manufacture and maintenance of chip cutting and cold deformation tools, excluding simple and mass-produced types
073 Manufacture of dies for cold stamping
074 Manufacture of moulds, chill moulds for hot working of metals
075 Moulds for plastics and similar materials
076 Manufacture of jigs, clamp jigs, templates and auxiliary manufacturing equipment in general
077 Light boilermaking services, ferrous and non-ferrous
078 Medium boilermaking services, up to 1 1/4" or 30 mm thickness
079 Manufacture of complete gears or gear-cutting only
080 Specialised precision machining
081 Specialised, medium and semi-heavy machining
082 Cold stamping
083 Manufacture of metal and similar labels for identification, instructions for use and maintenance
BLOCK C: COMPONENTS
C - FACTORS OF COMPONENTS
084 Mechanical components of one or few parts
085 Mechanical components, of several parts, up to 100-150 kg
086 Other mechanical components, of several parts
087 Hydraulic components
088 Pneumatic components
089 Vacuum components
090 Electrical components for control, measurement and related applications
091 Electrical components for power supply, and for misc. industrial uses
092 Electronic components
093 Electric motors, stepless motor variators, etc.
094 Components for linear, angular and plane measurement
095 Components for lubrication and eventual friction bearings
096 Cooling system components, with water or liquid circulation
097 Components for refrigeration
098 Components for steam and gas systems, corrosive and non-corrosive, all temperatures
099 Electrical instruments
100 Optical, infra-rad and similar instruments, rays in general
101 Instruments, other
102 Branch-specific metallic components
103 Branch-specific non-metallic components; selected list.

Figure 3.2 Factors of the analysis of technological complexity

and each level is assigned an index number. Total technological complexity index I_c of a product is the sum of complexity ratings assigned to different factors required by the specific technological production route chosen. The products are then grouped into six levels according to their total complexity ratings --levels I to VI, see Figure 3.3.

23. Figures 3.3, 3.4, 3.5, 3.6 and 3.7 show in turn the results of ATC carried out for the a sample group of capital goods (nearly 400 products): Agricultural machinery, food processing equipment, building construction machinery and capital goods common to all sectors.

24. The following observations can be made from the Figures 3.3 to 3.7:

- The weight of components (i.e. the difference between the total complexity and the complexity without components) is very low for simple machinery. The difference, however, becomes significant for sophisticated machinery indicating the importance of components in the manufacture of such equipment (Figure 3.4).

- Comparison of Figures 3.5, 3.6 and 3.7 with 3.4 indicates the product diversification possibilities which exist between the agricultural machinery and the capital goods for food processing, capital goods for building construction and capital goods common to all sectors.

- In particular, simple agricultural machinery and simple capital goods for building construction have similar properties such as small difference between the total complexity and the complexity without components; wide dispersion, etc. (Figures 3.6 and 3.4).

25. One of the conclusions from the ATC of several sub-sectors of the capital goods industry is that there are possibilities of diversification between sub-sectors for the manufacture of products of similar complexity levels. However, practical application of this conclusion has to be justified at production unit level and within the structure of industrial production of a given country (see Chapter 8 and 9).

26. For this purpose, an attempt is made to analyze the structure and required technological capabilities of production units of different complexity levels (see Chapter 8). There, the properties of production units are identified by using the technological production route and the technological complexity analysis. This, however, necessitates, for each

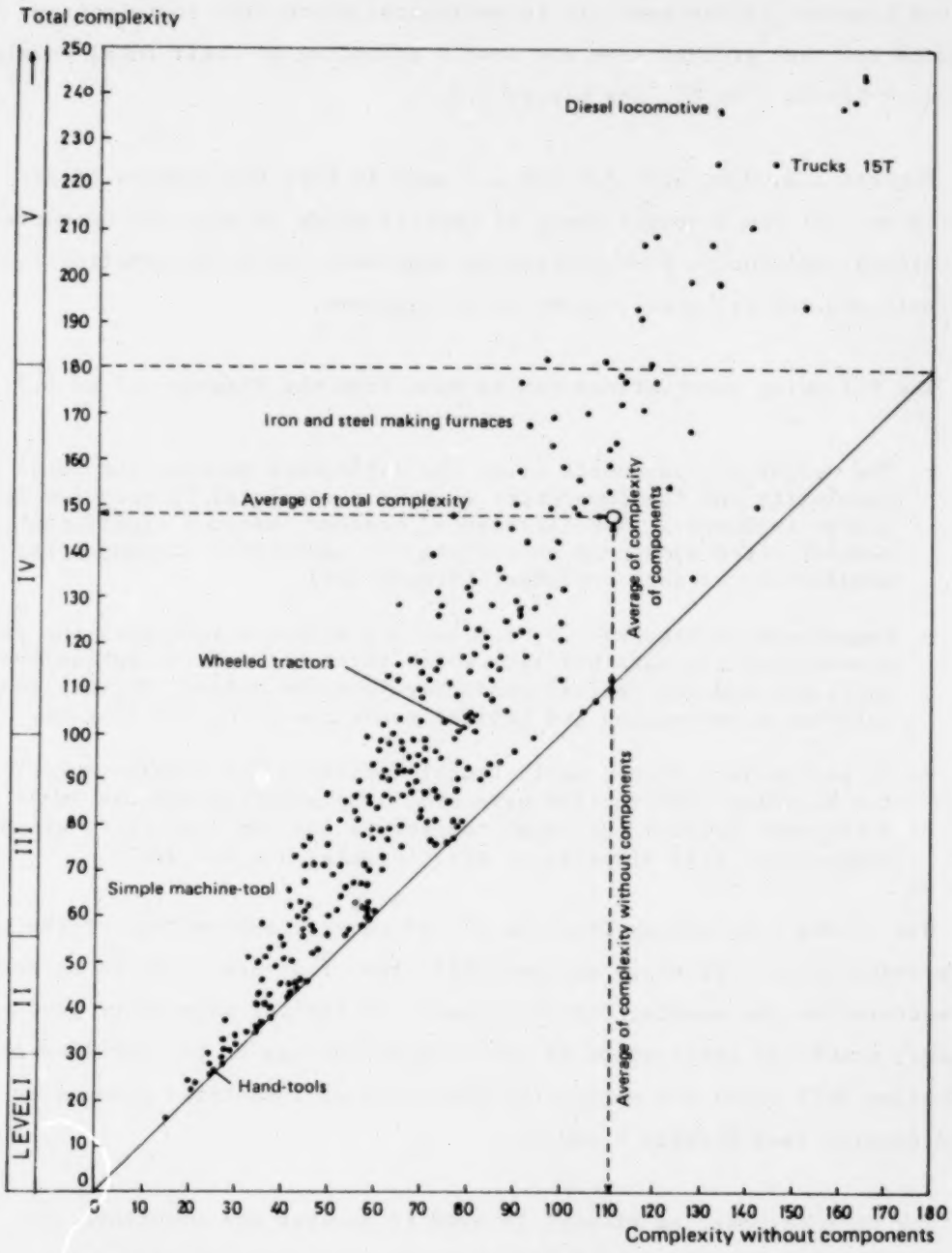

Figure 3.3 Dispersion of technological complexities of capital goods

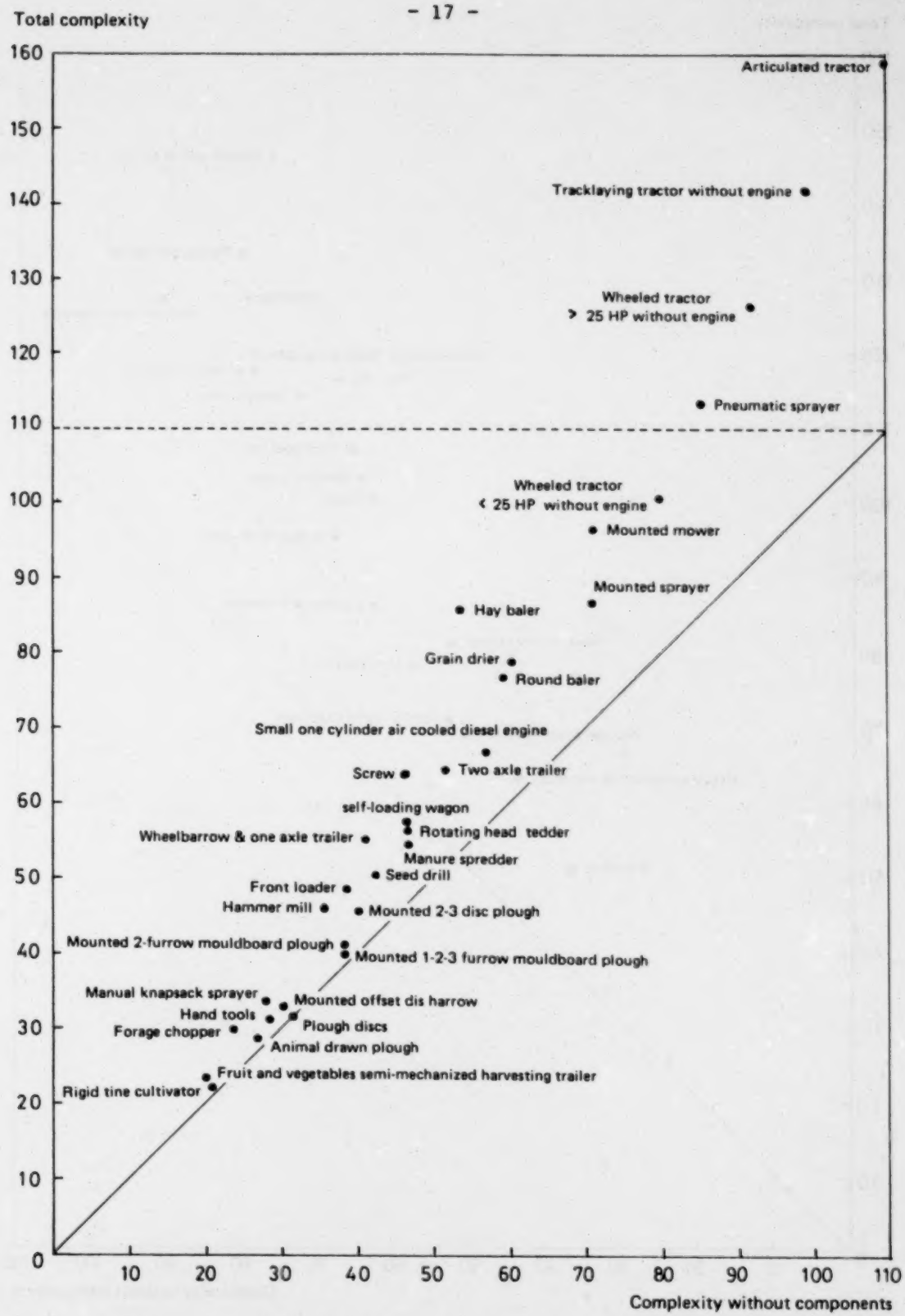

Figure 3.4 Dispersion of technological comlexities of agricultural machinery

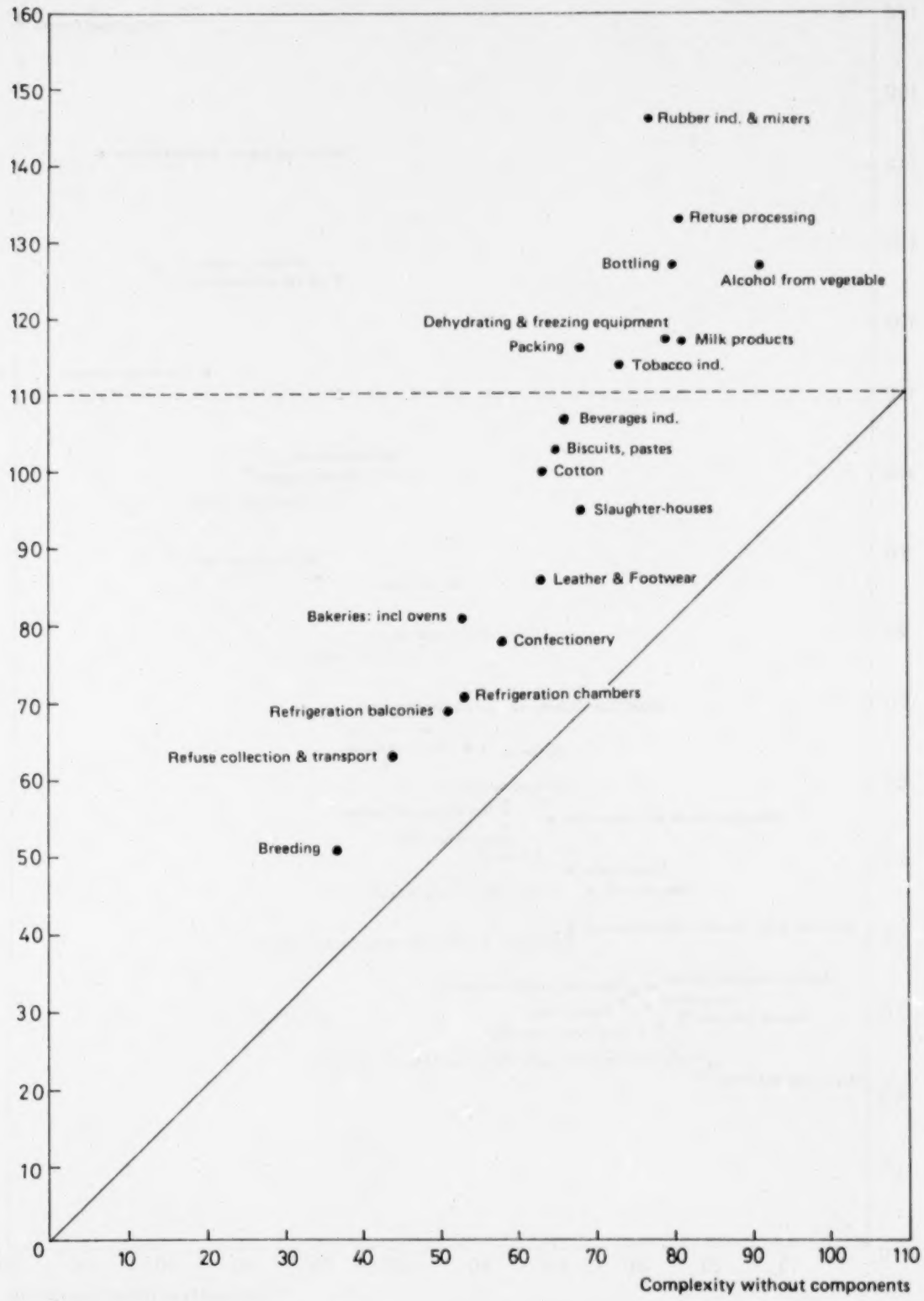

Figure 3.5 Dispersion of technological complexities of capital goods for food processing industries

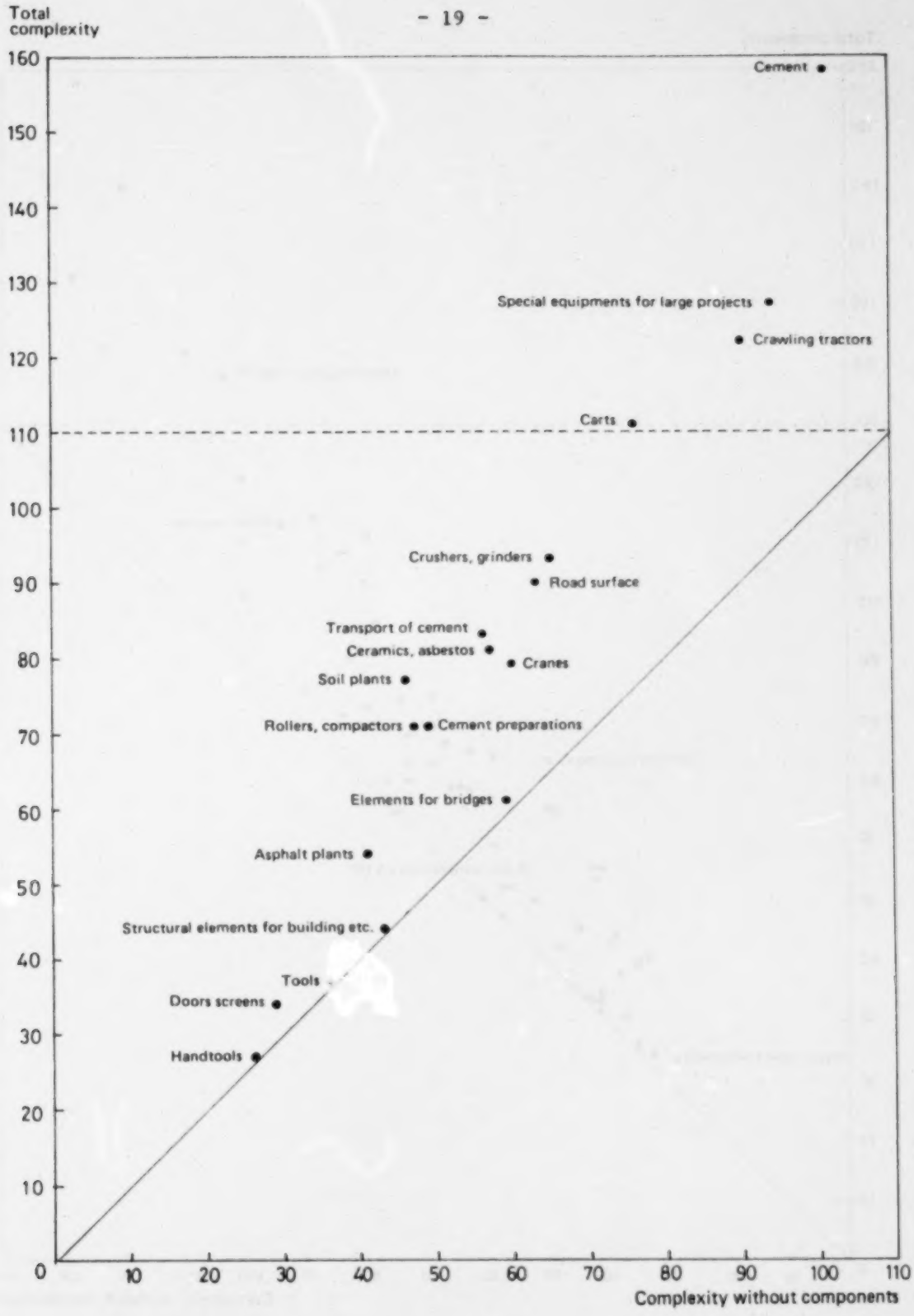

Figure 3.6 Dispersion of technological complexities of capital goods for building construction and building materials industry

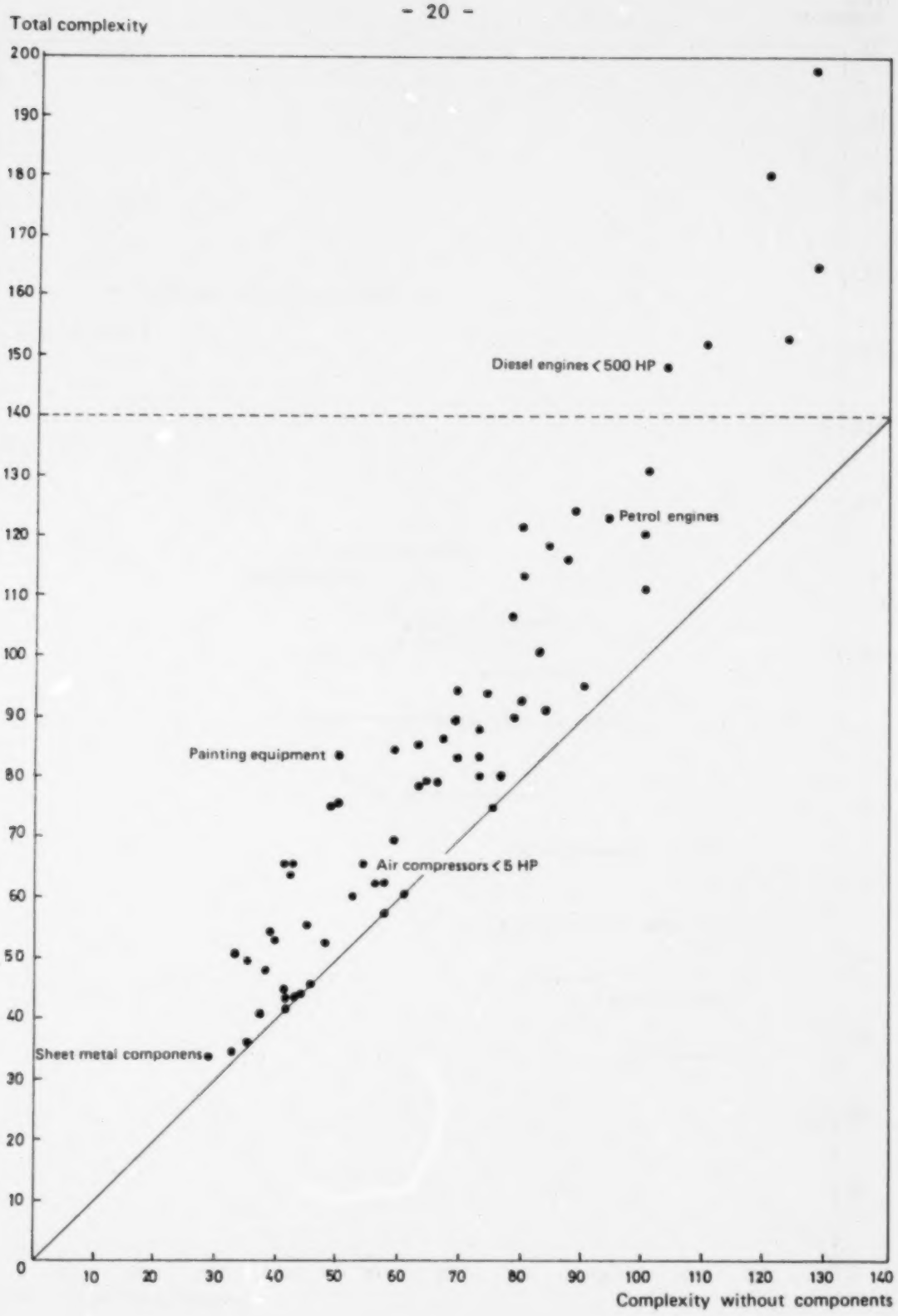

Figure 3.7 Dispersion of technological complexities of capital goods common to all sectors

product, the consideration of all 103 parameters for 6 complexity levels (see Table 3.1)[18/]. In order to simplify the analysis, 8 manufacturing processes and 4 complexity levels have been selected. These processes are widely used in the production of agricultural machinery and rural equipment, simple energy equipment, food processing machinery, etc. Table 3.2 summarizes the description of each process for four levels of technological complexity.

3.3 Utilization of ATC methodology

27. ATC is not the only method for the classification of capital goods[19/]. However, provided that its limitations are carefully observed, ATC is unique as it can be utilized in all of the following activities:

a) **At macro level:** Planning, identifying sectoral and sub-sectoral priorities, policy and strategy formulation, etc., in particular:

- Survey of existing capital goods production facilities;
- Classification of capital goods and identification of demand in terms of this classification;
- Selection of products and/or groups of products which would meet the identified demand of the country and, at the same time, would be compatible with the technological level of national industry;
- Identification of required technical services to be created.

b) **At micro level:**

- Project identification and design, and feasibility studies;
- Selection of product and/or process mixes, and identification of diversification and/or multipurpose operation possibilities;
- Precise identification of the required subcontracting services and types and quantities of components.

18/ An analysis of a group of agricultural machinery was carried out by using this method. Table 3.1 shows the resultant technological complexity ratings. In that work, 80 ATC factors were used; the number of factors has been increased to 103 during the subsequent development of the ATC methodology.

19/ UNIDO; Manual for planning of capital goods industries (by M.M. Luther, UNIDO Consultant), UNIDO/IO.584, 1983.

Table 3.1 ATC of a group of agricultural machinery

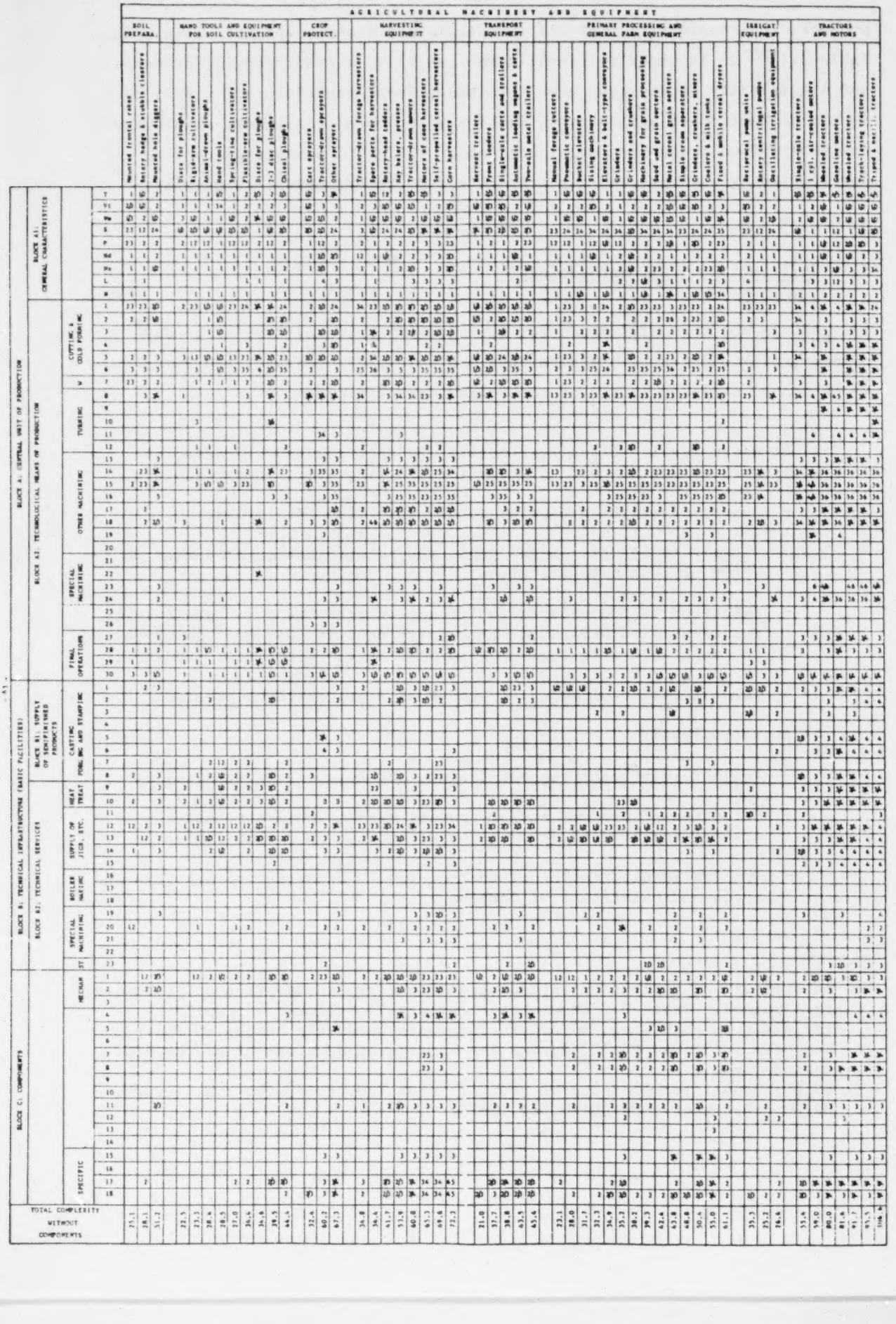

Table 3.2 Technical characterization of 4 levels of complexity of 8 processes

	FOUNDRY	FORGING	SHEET, TUBE AND PROFILE WORKING	HEAT TREATMENT
LEVEL I	-Manual sand preparation -Manual moulding with tools -Simple oil furnace smelting -Casting with smelted material hand transport -Hand shake-out and knock-out -Trimming with hand tools	-Simple oil- or coal-furnace heating -Loose tool forging -Hand snagging -Hand straightening	-Cutting with snips, hand hacksaw and hand torch, hand lever, shearing machine -Hand torch scribing -Hand bending -Hand 3-roller rolling	-Simple coal-burning, heating and water quenching tentative hardening
LEVEL II	-Sand preparation with mixing machine -Manual moulding with wooden patterns -Balanced blast cupola smelting -Casting with smelted-material crane transport -Hand shake-out and knock-out -Trimming with hand-controlled sand-blasting	-Oil or electric furnace heating -Hammer forging -Hand snagging and straightening	-Shearing machine and hacksaw machine cutting -Hand scribing -Use of punching, 3- roller rolling and bending machines -Limited sized machines	-Oil furnace heating -Hardening in high-heat heat salt bath -Possibility of tempering, normalizing, annealing
LEVEL III	-Sand preparation with mixing and proportioning machine -Machine moulding with pattern -Automatic furnace smelting -Semi-automatic casting and shake-out equipment -Shot blasting and cast cleaning machines -Tunnel sandblasting	-Electric furnace heating -Die press forging -Hot trimming machine -Straightening press	-Shearing machine and automatic sawing machine cutting -Electric etching pantograph scribing -Use of large sized punching press, 3-roller rolling bending machines -Use of limited sized hydraulic, eccentric shaft presses	-Gas heating in fully instrumented furnace -Possibility of case hardening, nitriding, etc. -Non-continuous working
LEVEL IV	-Fully automatic plant with machine preparation, smelting in checked charge electric automatic cupoloa, automatic casting, etc. special castings	-Induction heating -Close die forging -Automatic hot-trimming and straightening system	-Use of large sized press -Possibility of deep-drawing -Automatic forming pressing cycles	-Heat treatment continuous transfer line -Special treatments

Table 3.2 (continued)

	ASSEMBLING	MACHINING	ASSEMBLY LINE	TESTING & INSPECTION
LEVEL I	-Electrode arc-welding -No jigs	-Hand hacksaw cutting -Universal lathe turning -Drilling -Hand tapping and threading -Not very accurate machine-tools and no more workings	-Stationary assembly -Hand tools and fixtures	-Nil
LEVEL II	-Electrode arc-welding -Spot welding -Use of clamp jigs, small presses	-Hacksaw machine cutting -Hydrocopying lathe turning -Use of milling and shaping machines -Lathe tapping and threading -More accurate machine tools	-Stationary assembly -Electric hand tools and fixtures	-Sampling inspection -No test
LEVEL III	-Continuous rod arc-welding -Sheet flaging -Use of semi-automatic jigs, large presses drilling, grinding machines, gear cutting	-Automatic sawing machine cutting -Turret lathe turning -Use of broaching, boring, column	-Assembly line -Electric hand tools and fixtures	-Detailed inspection of parts and groups -Engine, group testing; balancing, final test
LEVEL IV	-Steam resistance welding -Automatic and special weldings -Robot multiple spot welding -Automatic jigs	-Use of all other available machine-tools (planning machine, special gear cutting machine, etc.; multiple-spindle lathe, drilling machine, etc.) -Use of numerical control machine tools and transfer machines -Special machining	-Fully automatic assembly line -Timed step conveyors	-Specific electronic inspection and testing

28. The full utilization of ATC is a long-term undertaking and necessitates the creation of dedicated teams of experts. UNIDO's field experience has shown that the method could be very effective at both levels mentioned above[20,21].

29. Although the Analysis of Technological Complexity (ATC) appears to be an excellent analytical tool, its usefulness would be best appreciated once its limitations are carefully reviewed:

- ATC may be subjective in the sense that it is, to some extent, dependent on the chosen technological model;
- Due to lack of reliable data, ATC does not, at present, directly include some factors such as energy efficiency of products and processes, repair and maintenance requirements of end products and production apparatus, intra-firm organizational and management aspects, marketing, etc.;
- Since ATC is technology and design dependent, it should be reviewed and up dated to include the developments in these areas;
- Economic aspects of production such as investment costs, production costs, critical factors affecting productivity and quality, etc. should separetely be considered since their direct coverage within the ATC is rather limited.

20/ UNIDO; Un diagnostic et une strategie pour le groupe d'entreprises de SN Metal, UNIDO/IO.468 and Add. 1, 1982.

21/ UNIDO; Project: "Développement de la méthodologie d'Analyse de la complexité Technologique pour les biens d'équipement en Tunisie", UF/TUN/84/216, 1984.

CHAPTER 4

A TYPOLOGY OF DEVELOPING COUNTRIES

4.1 Introduction

30. The aim of this part is to develop a methodological framework which can assist the decision-makers in developing countries in drawing up industrial policies and strategies to enter into and/or develop a capital goods industry[22,23].

31. In view of the different levels of industrial development achieved by the developing countries, ranging from the least developed countries (LDCs) to the newly industrializing countries (NICs), a differentiated approach is required. In some of the countries there is no capital goods industry, so that it will be necessary to consider a strategy for starting up the industry. In other countries, the national capital goods industry produces a wide range of equipment; there, it will be a question of consolidating the industry and of enabling it to produce the more sophisticated types of equipment and/or give it access to advanced technology. Between these two extremes, one can find almost all levels of development of this sector. It is beyond the scope of this paper to deal with every country individually. Therefore, the countries are grouped according to some common dominant characteristics.

32. Selection of capital goods for domestic production is an activity which should be carried out not only by taking into account the technological aspects of manufacturing, but also by considering the socio-economic realities and the political goals of the country. The typology should, therefore, be linked, on the one hand, to the types and technological production routes of the capital goods whose manufacture is envisaged, and, on the other hand, to the socio-economic conditions of the developing countries.

22/ Op. cit. 14/.
23/ UNIDO; Electric power equipment production in developing countries: A typology and element of strategy, UNIDO/IS.509, 1985.

33. At the world level, the capital goods industry is heavily concentrated in the developed countries[24/]. This statement is particularly true in the case of complex equipment. In the case of simpler equipment, however, the technology has been mastered in a growing number of developing countries. In this case, the respective bargaining capacities of the owner of technology and the developing country wishing to obtain it are very different from the case of complex equipment. Therefore, a typology of developing countries must also make it possible to take into account the different bargaining conditions for the transfer of technology.

34. As a general rule, the difficulties of negotiating a transfer of technology increase with the technological complexity of capital goods. This, in a sense, is favourable, since the developing countries with a low level of industrialization will negotiate for simpler technologies that are more easily available. It will be the most advanced developing countries that will negotiate the transfer of more complex technologies; these countries are those that have the strongest bargaining power.

35. In summary, the typology work should make it possible the preparation of strategies for the development of the capital goods industry which:

- Would take into account the differences in the industrialization level of the countries;
- Would help to identify the specific priority sectors of the economy for which the domestic production of capital goods can be planned;
- Are linked with the types and technological complexity of the products whose manufacture is envisaged;
- Would evaluate the country's bargaining power for the transfer of technology according to the structure of the capital goods industry at world level.

4.2 Methodology

36. **Selection of countries:** The availability of statistical data is the

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24/ Op. cit. 2/.
25/ International Bank for Reconstruction and Development/World Bank, World Development Report, 1984.

main factor affecting the selection process. The World Bank statistics appeared to be the most suitably arranged for the purpose of this study[25/]. They cover 91 developing countries with populations above one million. These countries are listed in Table 4.1.

37. A typology of developing countries may be developed by using a correlated set of macroeconomic, demographic, etc. indicators. Consequently, almost infinite number of typologies is theoretically possible. The limiting factor, however, is the availability of reliable data. Furthermore, the selected indicators may not be, in the real sense, true independent variables. The interdependency of these variables does not, however, appear to be an insurmountable obstacle to the present work.

38. For the purpose of this study, the typology of developing countries was developed in two stages:

a) Grouping of developing countries according to their level of industrialization, potential to enter into and/or develop a capital goods industry, and according to their bargaining power for the transfer of technology;

b) Sub-grouping of developing countries according to their sectoral priorities and corresponding types of products and technological production routes.

39. For the first stage of grouping, the following criteria and indicators were adopted:

a) Criterion : The size and development potential of the domestic market for capital goods.

Indicators:
- Population of the country;
- The share of industry (and manufacturing) in the GDP, in real value terms;
- Imports of machinery and transport equipment.

b) Criterion : Potential to enter into and/or develop a capital goods industry and bargaining power for the transfer of technology.

Indicators:
- Share of industry (and manufacturing) in GDP, in percent;
- Value added in manufacturing.

25/ International Bank for Reconstruction and Development/World Bank, World Development Report, 1984.

4.3 Presentation of results

40. The following data were collected for 91 developing countries and presented in Tables 4.1 and 4.2.

In Table 4.1:

i. Population, million inhabitants, in mid-1982;
ii. Area, thousend square kilometers;
iii. Gross Domestic Product (GDP), million US$, current prices, in 1982;
iv. Per capita Gross National Product (GNP), US$, current prices, in 1982;
v. Shares of the following sectors in GNP, percent, in 1982,
   - Agriculture,
   - Industry (and manufacturing), and
   - Services;
vi. Value-added in manufacturing (MVA), million US$, constant 1975 prices, in 1981;
vii. Value-added in machinery and transport equipment production, million US$, constant 1975 prices, in 1981 (in the case of countries for which information is not available, the position of the country was estimated in terms of five classes identified in para. 44 below).

In Table 4.2:

i. Exports, million US$, in 1982;
ii. Share of following merchandize exports in total exports, million US$, in 1981,
   - Fuels, minerals and metals,
   - Other primary commodities,
   - Textiles and clothing,
   - Machinery and transport equipment,
   - Other manufactures;
iii. Imports, million US$, in 1982;
iv. Imports of machinery and transport equipment, million US$, current 1982 prices, (estimated from percentage share of machinery and transport equipment in total imports in 1981 and total imports in 1982);
v. Share of imports of machinery and transport equipment in total imports, percent, in 1981.

41. Three graphs were prepared from the date given in Tables 4.1 and 4.2. In all graphs population was used as the common reference variable. Population was also used as the criterion for a first classification of developing countries:

P1: Countries with a small population, less than 5 million inhabitants;

P2: Countries with a **medium-sized** population, between 5 - 20 million inhabitants;

P3: Countries with a **large** population, more than 20 million inhabitants.

42. In Figure 4.1, developing countries are classified according to manufacturing value-added (MVA) in their industries. This parameter appears to indicate the size of market for capital goods. The following groups are identified;

M1: MVA less than US$ 500 million, **small market**;

M2: MVA between US$ 500 - 10,000 million, **medium-to-large market**;

M3: MVA more than US$ 10,000 million, **very large market**.

43. Figure 4.2 classifies the developing countries according to their imports of machinery and transport equipment in 1982. These imports, even calculated for a single year, give also an indication of the size of domestic market. Three groups can be identified:

I1: Countries with a **low** level of imports, less than US$ 500 million;

I2: Countries with a **medium** level of imports, between US$ 500 - 3,000 million;

I3: Countries with a **high** level of imports, more than US$ 3,000 million.

44. Figure 4.3 classifies the developing countries according to their production of machinery and transport equipment measured in terms of manufacturing value-added (MVA). This classification indicates the development stage of capital goods industry (or production capacity) and, probably, the level of technological complexity of products manufactured. The following groups are identified:

C1: MVA less than US$ 20 million, **very low capacity**;

C2: MVA between US$ 20 - 60 million, **low capacity**;

C3: MVA between US$ 60 - 300 million, **medium-level capacity**;

C4: MVA between US$ 300 - 1,000 million, **large capacity**;

C5: MVA more than US$ 1,000 million, **very large capacity**.

4.4 Final grouping of developing countries

45. The first stage of typology has been completed by identifying the following three groups which are shown in Table 4.3:

a) Group A: Countries with a very large market, very large capacity and high bargaining power (i.e., Newly Industrializing Countries --NICs), 7 countries;

b) Group B: Countries with a medium market, medium-to-large capacity and medium bargaining power, 30 countries;

c) Group C: Countries with low-to-medium market, very low-to-low capacity and very low-to-low bargaining power, 54 countries.

4.5 Sectoral priorities and entry routes

46. The second phase of the typology work has been carried out in line with the goals set forth in Chapter 1. In this context, special emphasis was given to Group C countries which have no or only an embryonic capital goods industry.

47. At the First Consultation on the Capital Goods Industry, the major problem of Group C countries was identified as the starting up the capital goods industry (or entering into the sector)[26/]. Selection of entry route, however, necessitates, among others, the correct identification of priority sectors and selection of corresponding priority products and their technological production routes.

48. It is true that each one of the Group C countries shown in Table 4.4 may have its own unique socio-economic and technological characteristics, and political goals. It is, again, beyond the scope of this paper to deal with each country separately; therefore, another grouping is required.

49. Reclassification of Group C countries according to the type and size of their sectoral activities is, therefore, necessary to identify those priority sectors which are common to some sub-groups. For this purpose, and in

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26/ Op. cit. 13/.

addition to the data given in Tables 4.1 and 4.2, the following information was collected for Group C countries and presented in Table 4.4[27/]:

i. Distribution of labour force, percent, in 1980, among
   - Agriculture,
   - Industry, and
   - Services;

ii. Urban population as a percentence of total population, in 1982.

50. Considering the importance of agriculture within Group C, the criterion has been selected to evaluate the size of agricultural sector and its impact on the economy of each country. The following indicators were utilized:

a) Share of agriculture in GDP, percent, in 1982;

b) Share of agricultural labour force in total labour force, percent, in 1980;

c) Share of exports of agricultural commodities in total exports, percent, in 1981.

51. Three graphs were prepared from the data given in Tables 4.1, 4.2 and 4.4. In all graphs, population was used as the common reference variable. In Figures 4.4, 4.5 and 4.6, the Group C countries are classified as follows:

a) In Figure 4.4 (share of agriculture in GDP vs. population):

   A1: Countries with a share of agriculture in GDP less than 25%;

   A2: Countries with a share of agriculture in GDP more than 25%;

b) In Figure 4.5 (share of agricultural labour force in total labour force vs. population):

   L1: Countries with less than 50% of the labour force in agriculture;

   L2: Countries with more than 50% of the labour force in agriculture;

c) In Figure 4.6 (share of agricultural exports in total exports vs. population):

   E1: Countries with a share of agricultural exports in total exports less than 50%;

   E2: Countries with a share of agricultural exports in total exports more than 50%.

27/ Op. cit. 25/.

52. From the data given in Figures 4.4., 4.5 and 4.6, and corresponding classifications made; the following sub-groups of Group C countries were identified (see Table 4.5)[28/]:

a) **Sub-group C1:** Purely agricultural countries which are simultaneously in A2, L2 and E2, 27 countries;

b) **Sub-group C2:** Strongly agricultural countries which are simultaneously in A2 and L2, 14 countries;

c) **Sub-group C3:** Other 13 countries.

53. In Sub-group C1 countries, agriculture is the economic base. In many countries, subsistance agriculture is the main economic activity of the majority of population (see Table 4.4 for urbanization ratios). Without exception, development of agriculture in general, and rural development in particular, are the national objectives of these countries. Therefore, the manufacture of agricultural machinery and rural equipment (including food processing machinery and simple equipment for new and renewable sources of energy) can be identified as the entry route. In addition to standard agricultural machinery compatible with the local conditions, the manufacture of special machinery required by the cash crops (such as coffee, cotton, etc.) should also be considered. Further discussion on this issue will be made in Chapters 7 and 9.

54. Sub-group C2 countries have also a dominant agricultural sector. Therefore, agricultural machinery appears to be an appropriate entry route into the capital goods industry. However, many of the countries in this sub-group have dual economies, i.e., the activities are concentrated in two sectors, one being always the agriculture which forms the backbone of the economy. The second sector, in most of the cases, is mining (for example, in Angola: Oil, iron ore, diamonds; in Guinea: Bauxite, iron ore, diamonds; in Liberia: Iron ore; in Mauritania: Iron ore, gypsum; in Niger: Uranium; in Sierra Leone: Diamonds; in Togo: Phosphates; in Zaire: Cobalt, copper, diamonds).

28/ When information for a specific country was not available from the World Bank statistics, the supplementary data was obtained from: "Banks, A.S. et al. (editors); 1981 Economic Handbook of the World, McGraw-Hill, New York, 1981" or "UNCTAD; The least developed countries 1984 report, TD/B/1027, 1984".

55. In a number of Sub-group C2 countries economy in general, and export earnings in particular, depend on processing of agro-products such as coffee, groundnut, fish, cotton, etc. Furthermore, textile industry has priority in cotton and/or wool producing countries.

56. For Sub-group C2 countries, one entry route is the integrated manufacture of agricultural machinery and rural equipment, food processing equipment and simple mining structures and machinery. In those countries in which mining has been active for some time, the already existing repair and maintenance facilities could be developed to manufacture first the spare parts, and later, some of the related simple machinery.

57. In Sub-group C3 countries, one (or more) sector(s) other than agriculture has a dominant role in the economy. This sector can be mining (for example, in Bolivia: Tin, petroleum and natural gas, zinc; in Congo: Silver, ferronickel; in Jamaica: Bauxite; in Jordan: Phosphates; in Libya: Oil; in Oman: Oil; in Trinidad and Tobago: Oil; in United Arab Emirates: Oil), or textiles, or petroleum processing, or re-exporting, or services.

58. It appears that, although the manufacture of mining structures and machinery and/or repair and maintenance activities with regard to mining operations could establish one entry route into capital goods sector, each country in Sub-group C3 may have its own specific priorities. The heterogenity of this sub-group makes it difficult to identify common entry routes.

59. Entry possibilities through the agricultural machinery industry will further be discussed in Chapter 9.

Table 4.1 Statistical data on developing countries

		Population 10^6 1982	Area sq.km. 10^3	GDP US$ 10^6 1982	GNP/cap. US$ 1982	Distribution of GNP %, 1982 Agr	Ind	Man	Ser	MVA est. 1975 US$ 10^6 1981	(*)
1	Afghanistan	16.8	648	..	..	..	..	..	..	..	C1
2	Algeria	19.9	2,382	44,930	2,350	6	55	10	39	3,125	313
3	Angola	8.0	1,247	..	..	..	..	..	..	..	C2
4	Argentina	28.4	2,767	64,450	2,520	9	38	25	53	10,612	2,441
5	Bangladesh	92.9	144	10,940	140	47	14	7	39	1,290	52
6	Benin	3.7	113	830	310	44	13	7	43	56	C1
7	Bhutan	1.2	47	..	..	..	..	..	..	..	C1
8	Bolivia	5.9	1,099	7,160	570	17	27	14	56	390	C2
9	Brazil	126.8	8,512	248,470	2,240	13	34	27	53	40,673	9,762
10	Burkina Faso	6.5	274	1,000	210	41	16	12	43	96	C1
11	Burma	34.9	677	5,900	190	48	13	9	39	456	5
12	Burundi	4.3	28	1,110	280	56	17	10	27	44	C1
13	Cameroon	9.3	475	7,370	890	27	31	11	42	477	10
14	Central African R	2.4	623	660	310	35	19	8	46	29	C1
15	Chad	4.6	1,284	400	80	64	7	4	29	21	C1
16	Chile	11.5	757	24,140	2,210	6	34	20	60	2,161	303
17	China	1,008.2	9,561	260,400	310	37	41	..	22	..	C5
18	Colombia	27.0	164	34,970	1,460	26	31	21	42	3,260	359
19	Congo, PR	1.7	342	2,170	1,180	6	52	5	42	104	C1
20	Costa Rica	2.3	51	2,580	1,430	25	27	20	48	531	C2
21	Cuba	9.8	115	..	..	..	..	..	..	..	C2
22	Dominican R	5.7	49	7,320	1,330	18	28	16	54	956	10
23	Ecuador	8.0	284	12,330	1,350	11	40	12	49	887	89
24	Egypt Arab R	44.3	1,001	26,400	690	20	34	27	46	4,544	636
25	El Salvador	5.1	21	3,680	700	22	20	15	58	270	C2
26	Ethiopia	32.9	1,222	4,010	140	49	16	11	36	349	C1
27	Ghana	12.2	239	31,220	360	51	8	5	41	505	C2
28	Guatemala	7.7	109	8,730	1,130	..	..	..	..	..	C2
29	Guinea	5.7	246	1,750	310	41	23	2	36	26	C1
30	Haiti	5.2	28	1,640	300	..	..	..	..	..	C1
31	Honduras	4.0	112	2,520	660	27	27	17	46	254	3
32	India	717.0	3,288	150,760	260	33	26	16	41	16,190	3,238
33	Indonesia	152.6	1,919	90,160	580	26	39	13	35	5,998	420
34	Iran, Islamic R	41.2	1,648	..	..	..	..	..	..	..	C4
35	Iraq	14.2	435	..	..	..	..	..	..	..	C3

(..): No data available
(.) : Less than one
(*) : MVA in machinery and transport equipment, US$ million (constant 1975 prices), in 1981. When the data was not available, the position of the country was estimated in terms of capacity classes given in para. 44.

Table 4.1 (continued)

		Population 10^6 1982	Area sq.km. 10^3	GDP US$ 10^6 1982	GNP/cap. US$ 1982	Distribution of GNP %, 1982 Agr	Ind	Man	Ser	MVA cst. 1975 US$ 10^6 1981	(*)
36	Ivory Coast	8.9	322	7,560	950	26	23	12	51	706	C3
37	Jamaica	2.2	11	3,180	1,330	7	32	16	61	329	C2
38	Jordan	3.1	98	3,500	1,690	7	29	14	64	286	C2
39	Kampuchea, D	7.0	181	..	..	..	..	..	..	..	C1
40	Kenya	18.1	583	5,340	390	33	22	13	45	531	175
41	Korea, DR	18.7	121	..	..	..	..	..	..	..	C3
42	Korea, R of	39.3	98	68,420	1,910	16	39	28	45	10,542	1,898
43	Kuwait	1.6	18	20,060	19,870	1	61	7	38	986	C2
44	Lao, PDR	3.6	237	..	..	..	..	..	..	..	C1
45	Lebanon	2.6	10	..	..	..	..	..	..	..	C2
46	Lesotho	1.4	30	300	510	23	22	6	55	10	C1
47	Liberia	2.0	111	950	490	36	28	7	36	39	C1
48	Libya	3.2	1,760	28,360	8,510	2	68	3	30	544	C2
49	Madagascar	9.2	587	2,900	320	41	15	..	44	272	5
50	Malaysia	14.5	330	25,870	1,860	23	30	18	47	2,918	525
51	Malawi	6.5	118	1,320	210	43	20	13	37	81	C1
52	Mali	7.1	1,240	1,030	180	43	10	5	47	55	C1
53	Mauritania	1.6	1,031	640	470	29	25	8	46	36	C1
54	Mexico	73.1	1,973	171,270	2,270	7	38	21	55	31,115	6,223
55	Morocco	20.3	447	14,700	870	18	31	16	51	1,960	176
56	Mozambique	12.9	802	..	..	..	..	..	..	..	C2
57	Nepal	15.4	141	2,510	170	..	..	..	..	..	C1
58	Nicaragua	2.9	130	2,940	920	21	32	26	47	360	C2
59	Niger	5.9	1,267	1,560	310	31	30	8	39	172	C1
60	Nigeria	90.6	924	71,720	860	22	39	6	39	4,020	482
61	Oman	1.1	300	7,110	6,090	..	..	..	..	..	C1
62	Pakistan	87.1	804	24,660	380	31	25	17	44	2,496	175
63	Panama	1.9	77	4,190	2,120	10	21	10	69	280	6
64	Papua New Guinea	3.1	462	2,350	820	..	..	..	..	132	C1
65	Paraguay	3.1	407	5,850	1,610	26	26	16	48	430	43
66	Peru	17.4	1,285	21,620	1,310	8	39	24	53	4,038	404
67	Philippines	50.7	300	39,850	820	22	36	24	42	5,706	571
68	Rwanda	5.5	26	1,260	260	46	22	16	32	106	C1
69	Saudi Arabia	10.0	2,150	153,590	16,000	1	77	4	22	3,568	C3
70	Senegal	6.0	196	2,510	490	22	25	15	53	298	C2

(..): No data available
(.) : Less than one
(*) : MVA in machinery and transport equipment, US$ million (constant 1975 prices), in 1981. When the data was not available, the position of the country was estimated in terms of capacity classes given in para. 44.

Table 4.1 (continued)

		Population 10^6 1982	Area sq.km. 10^3	GDP US$ 10^6 1982	GNP/cap. US$ 1982	Distribution of GNP %, 1982 Agr	Ind	Man	Ser	MVA est. 1975 US$ 10^6 1981	(*)
71	Sierra Leone	3.2	72	1,130	390	32	20	5	48	37	C1
72	Singapore	2.5	1	14,650	5,910	1	37	26	62	2,556	1,406
73	Somalia	4.5	638	..	290	..	..	..	..	..	C1
74	Sri Lanka	15.2	66	4,400	320	27	27	15	46	714	C2
75	Sudan	20.2	2,506	9,290	440	36	14	7	50	421	C2
76	Syrian Arab R	9.5	185	15,240	1,680	19	31	..	50	1,318	53
77	Tanzania	19.8	945	4,530	280	52	15	9	33	202	C2
78	Thailand	48.5	514	36,790	790	22	28	19	50	4,636	695
79	Togo	2.8	57	800	340	23	29	6	48	14	C1
80	Trinidad and Tobago	1.1	5	6,970	6,840	2	52	13	46	434	39
81	Tunisia	6.7	164	7,090	1,390	15	36	13	49	820	66
82	Uganda	13.5	236	8,630	230	82	4	4	14	87	C1
83	United Arab Emirates	1.1	84	29,870	23,770	1	77	4	22	..	C1
84	Uruguay	2.9	176	9,790	2,650	8	33	26	59	960	106
85	Venezuela	16.7	912	69,490	4,140	6	42	16	52	5,531	442
86	Viet Nam	57.0	330	..	..	..	..	..	..	..	..
87	Yemen Arab R	7.5	195	3,210	500	26	17	7	56	102	C1
88	Yemen, PDR	2.0	333	630	470	12	27	..	61	59	C1
89	Zaire	30.7	2,345	5,380	190	32	24	3	44	163	C1
90	Zambia	6.0	753	3,830	640	14	36	19	50	444	44
91	Zimbabwe	7.5	391	5,900	850	15	35	25	50	969	97

(..): No data available
(.) : Less than one
(*) : MVA in machinery and transport equipment, US$ million (constant 1975 prices), in 1981. When the data was not available, the position of the country was estimated in terms of capacity classes given in para. 44.

Table 4.2 Additional statistical data on developing countries

		Exports US$ 10^6 1982	Share of merchandize exports %, 1981					Imports US$ 10^6 1982	Imports of machin & trans eq US$ 10^6 1982	Share of mach&trans eq in total exports %, 1981
			Fuels mine & metals	Other prim commo	Textil &cloth ing	Machi trans equip	Other manu fact			
1	Afghanistan	373	..	..	..	..	..	776	..	(..)
2	Algeria	12,533	99	1	.	.	.	10,937	4,156	(38)
3	Angola	1,730	..	..	..	..	..	1,001	..	(..)
4	Argentina	7,798	8	72	1	5	14	5,337	2,295	(43)
5	Bangladesh	769	.	32	56	1	11	2,300	483	(21)
6	Benin	34	..	..	..	..	..	889	..	(..)
7	Bhutan	..	..	..	..	..	..	..	..	(..)
8	Bolivia	832	86	11	.	1	2	496	218	(44)
9	Brazil	18,627	14	45	4	18	19	19,936	3,588	(18)
10	Burkina Faso	56	.	85	2	6	7	346	83	(24)
11	Burma	380	..	..	..	..	..	408	..	(..)
12	Burundi	88	.	99	.	.	1	214	47	(22)
13	Cameroon	998	33	64	1	.	2	1,205	410	(34)
14	Central African R	106	.	74	.	.	26	91	31	(34)
15	Chad	101	..	..	..	..	..	132	..	(..)
16	Chile	3,822	65	25	.	2	8	3,529	1,165	(33)
17	China	21,875	24	23	21	5	27	19,009	5,132	(27)
18	Colombia	3,095	2	70	8	3	17	5,478	2,027	(37)
19	Congo, PR	923	90	4	.	.	6	970	223	(23)
20	Costa Rica	872	1	67	4	4	24	887	195	(22)
21	Cuba	1,328	5	90	0	0	5	1,415	..	(..)
22	Dominican R	768	2	79	.	1	18	1,256	251	(20)
23	Ecuador	2,341	56	41	1	1	1	2,189	1,073	(49)
24	Egypt Arab R	3,120	69	23	7	.	1	9,078	2,542	(28)
25	El Salvador	704	7	56	14	3	20	883	106	(12)
26	Ethiopia	404	8	91	.	.	1	787	245	(35)
27	Ghana	873	..	..	..	..	..	705	..	(..)
28	Guatemala	1,120	2	69	5	2	22	1,362	218	(16)
29	Guinea	411	..	..	..	..	..	296	..	(..)
30	Haiti	380	..	..	..	..	..	525	..	(..)
31	Honduras	654	6	83	2	.	9	712	192	(27)
32	India	8,446	8	33	23	8	28	14,088	1,831	(13)
33	Indonesia	22,294	83	13	1	1	1	16,859	6,069	(36)
34	Iran, Islamic R	16,379	..	..	..	..	..	11,231	4,942	(44)
35	Iraq	11,210	..	..	..	..	..	21,182	..	(..)

(..): No data available
(.) : Less than one

Table 4.2 (continued)

		Exports US$ 10^6 1982	Share of merchandise exports %, 1981					Imports US$ 10^6 1982	Imports of machin & trans eq US$ 10^6 1982	Share of mach&trans eq in total exports %, 1981
			Fuels mine & metals	Other prim commo	Textil &cloth ing	Machi trans equip	Other manu fact			
36	Ivory Coast	2,235	8	82	3	2	5	2,090	460	(22)
37	Jamaica	726	81	13	1	1	4	1,372	206	(15)
38	Jordan	753	33	24	6	2	35	3,241	1,070	(33)
39	Kampuchea, D	40	..	..	..	..	..	62	..	(..)
40	Kenya	979	36	52	.	1	11	1,683	471	(28)
41	Korea, DR	843	..	..	..	..	..	899	..	(..)
42	Korea, R of	21,853	2	8	30	22	38	24,251	5,578	(23)
43	Kuwait	16,561	84	1	1	5	9	8,042	3,297	(41)
44	Lao, PDR	24	..	..	..	..	..	83	..	(..)
45	Lebanon	923	..	..	..	..	..	3,567	..	(..)
46	Lesotho	..	..	..	..	..	..	..	..	(..)
47	Liberia	531	67	31	.	1	1	477	119	(25)
48	Libya	16,391	100	.	.	.	.	15,414	5,857	(38)
49	Madagascar	433	13	79	4	1	3	522	209	(40)
50	Malaysia	11,789	36	44	3	12	5	12,543	4,641	(37)
51	Malawi	262	.	93	5	.	2	314	107	(34)
52	Mali	146	..	..	..	..	..	332	..	(..)
53	Mauritania	232	..	..	..	..	..	273	..	(..)
54	Mexico	21,006	39	22	3	19	17	15,042	7,521	(50)
55	Morocco	2,059	44	28	10	1	17	4,315	820	(19)
56	Mozambique	303	..	..	..	..	..	792	..	(..)
57	Nepal	46	.	69	24	0	7	252	81	(32)
58	Nicaragua	406	2	88	1	.	9	776	163	(21)
59	Niger	333	81	17	1	.	1	442	115	(26)
60	Nigeria	19,484	95	4	.	.	1	20,821	8,120	(39)
61	Oman	4,421	94	1	.	4	5	2,682	1,046	(39)
62	Pakistan	2,403	7	40	41	1	11	5,396	1,241	(23)
63	Panama	309	24	67	3	.	6	1,569	329	(21)
64	Papua New Guinea	799	46	52	.	.	2	1,029	..	(..)
65	Paraguay	330	.	88	.	.	12	581	209	(36)
66	Peru	3,230	64	19	8	2	7	3,787	1,856	(49)
67	Philippines	5,010	16	39	7	3	35	8,229	1,893	(23)
68	Rwanda	90	..	..	..	..	..	286	..	(..)
69	Saudi Arabia	79,123	99	.	.	.	1	40,654	16,262	(40)
70	Senegal	477	52	29	4	4	11	974	175	(18)

(..): No data available
(.) : Less than one

Table 4.2 (continued)

		Exports US$ 10^6 1982	Share of merchandise exports %, 1981					Imports US$ 10^6 1982	Imports of machin & trans eq US$ 10^6 1982	Share of mach&trans eq in total exports %, 1981
			Fuels mine & metals	Other prim commo	Textil &cloth ing	Machi trans equip	Other manu fact			
71	Sierra Leone	111	..	..	..	..	..	298	..	(..)
72	Singapore	20,788	29	15	4	26	26	28,167	7,887	(28)
73	Somalia	317	5	94	.	.	1	378	132	(35)
74	Sri Lanka	1,015	14	65	16	.	5	1,771	407	(23)
75	Sudan	499	5	94	1	.	.	1,285	283	(22)
76	Syrian Arab R	2,026	74	18	4	1	3	4,015	923	(23)
77	Tanzania	480	10	76	9	0	5	1,046	366	(35)
78	Thailand	6,945	8	65	10	5	12	8,548	2,222	(26)
79	Togo	213	52	33	1	1	13	526	110	(21)
80	Trinidad and Tobago	3,072	90	2	.	3	5	3,697	813	(22)
81	Tunisia	1,960	57	10	15	2	16	3,294	889	(27)
82	Uganda	371	..	..	..	..	..	339	..	(..)
83	United Arab Emirates	16,883	..	..	..	..	..	9,419	3,391	(36)
84	Uruguay	1,023	1	69	13	2	15	1,042	333	(32)
85	Venezuela	16,443	97	.	.	1	2	11,670	5,018	(43)
86	Viet Nam	188	..	..	..	..	..	637	..	(..)
87	Yemen Arab R	44	.	49	6	25	20	1,987	556	(28)
88	Yemen, PDR	580	75	25	.	.	.	1,193	274	(23)
89	Zaire	569	..	..	..	..	..	480	..	(..)
90	Zambia	1,059	..	..	..	..	..	831	..	(..)
91	Zimbabwe	663	..	..	..	..	..	704	..	(..)

(..): No data available
(.) : Less than one

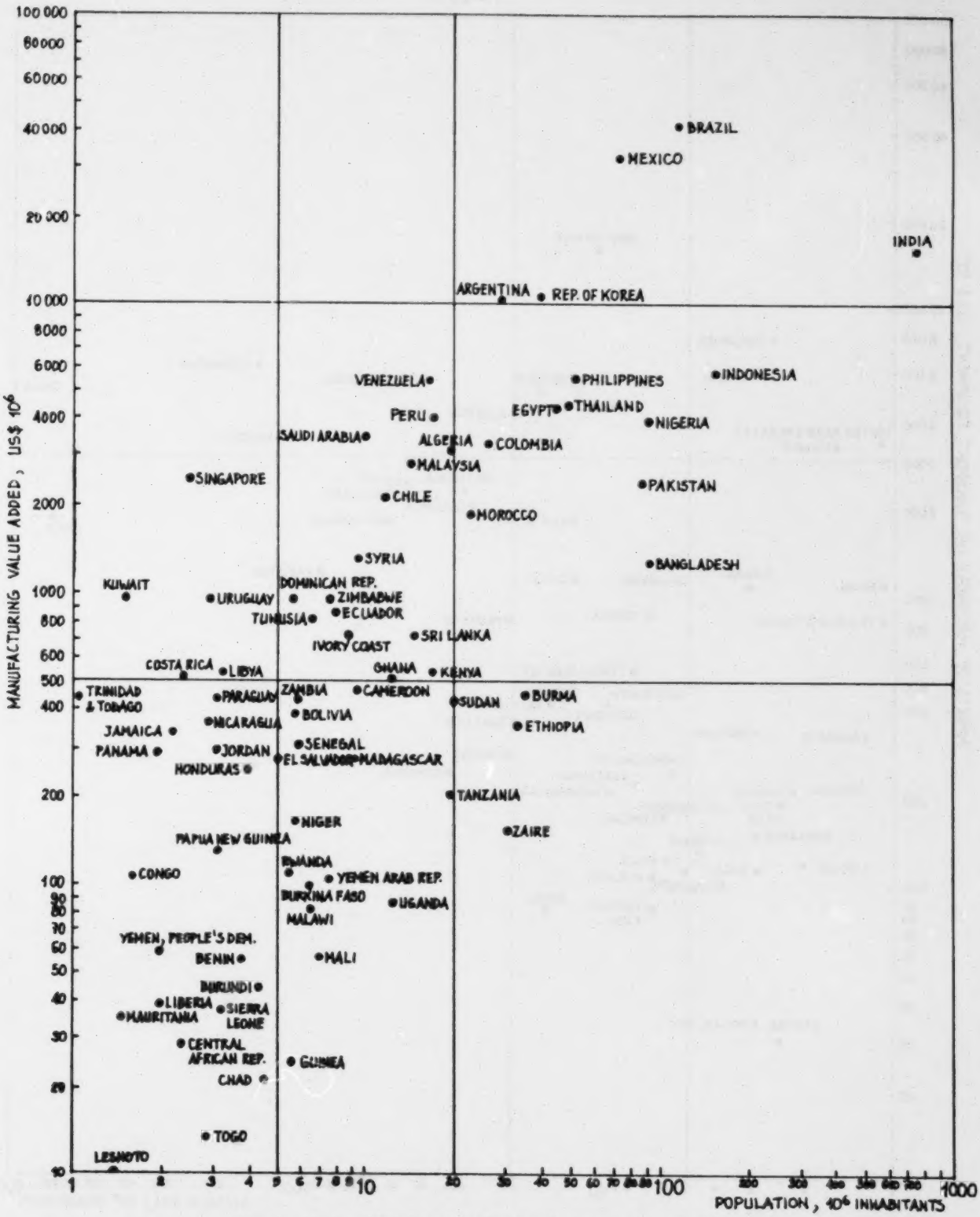

Figure 4.1 MVA in manufacturing vs. population

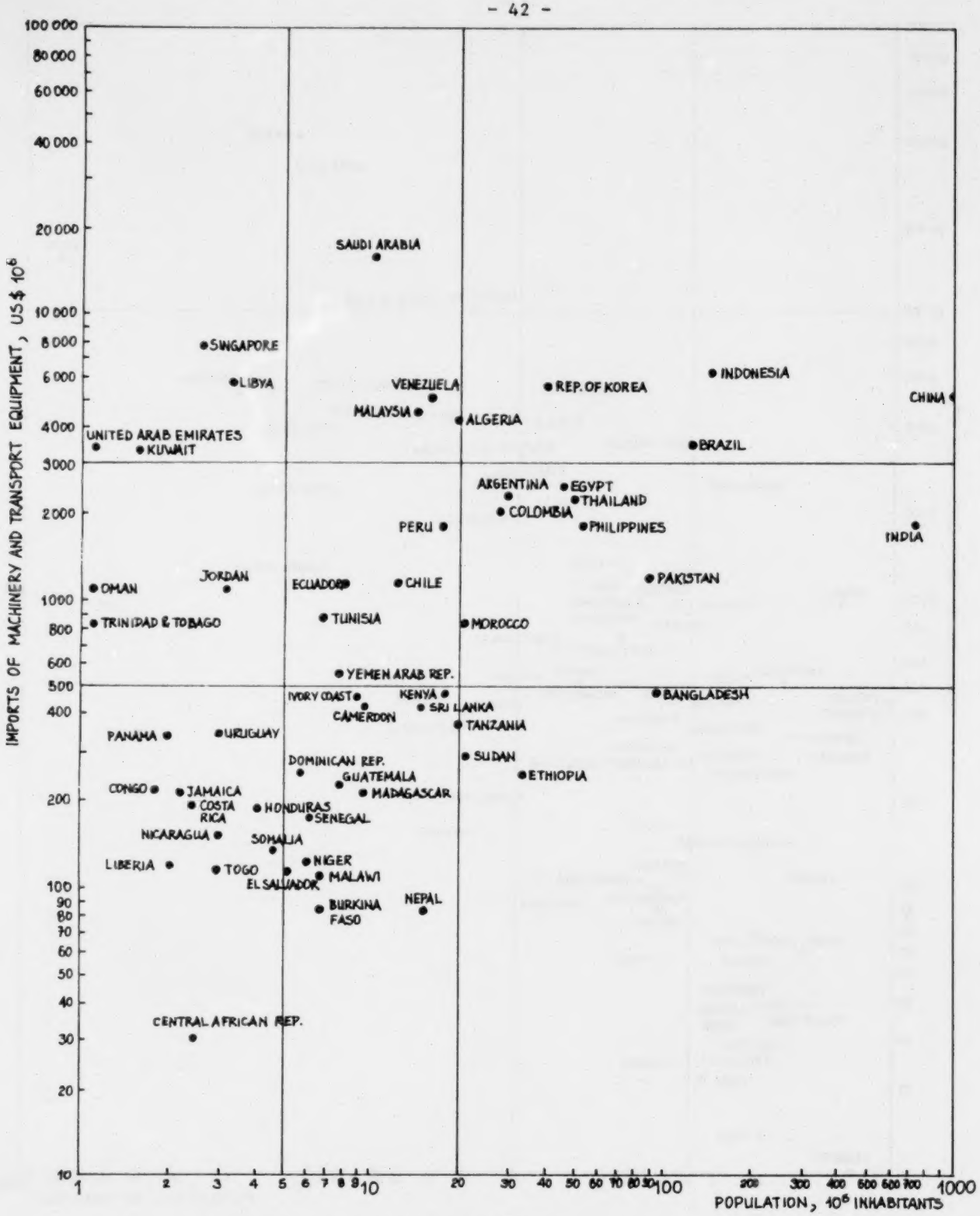

Figure 4.2 Imports of machinery and transport equipment vs. population

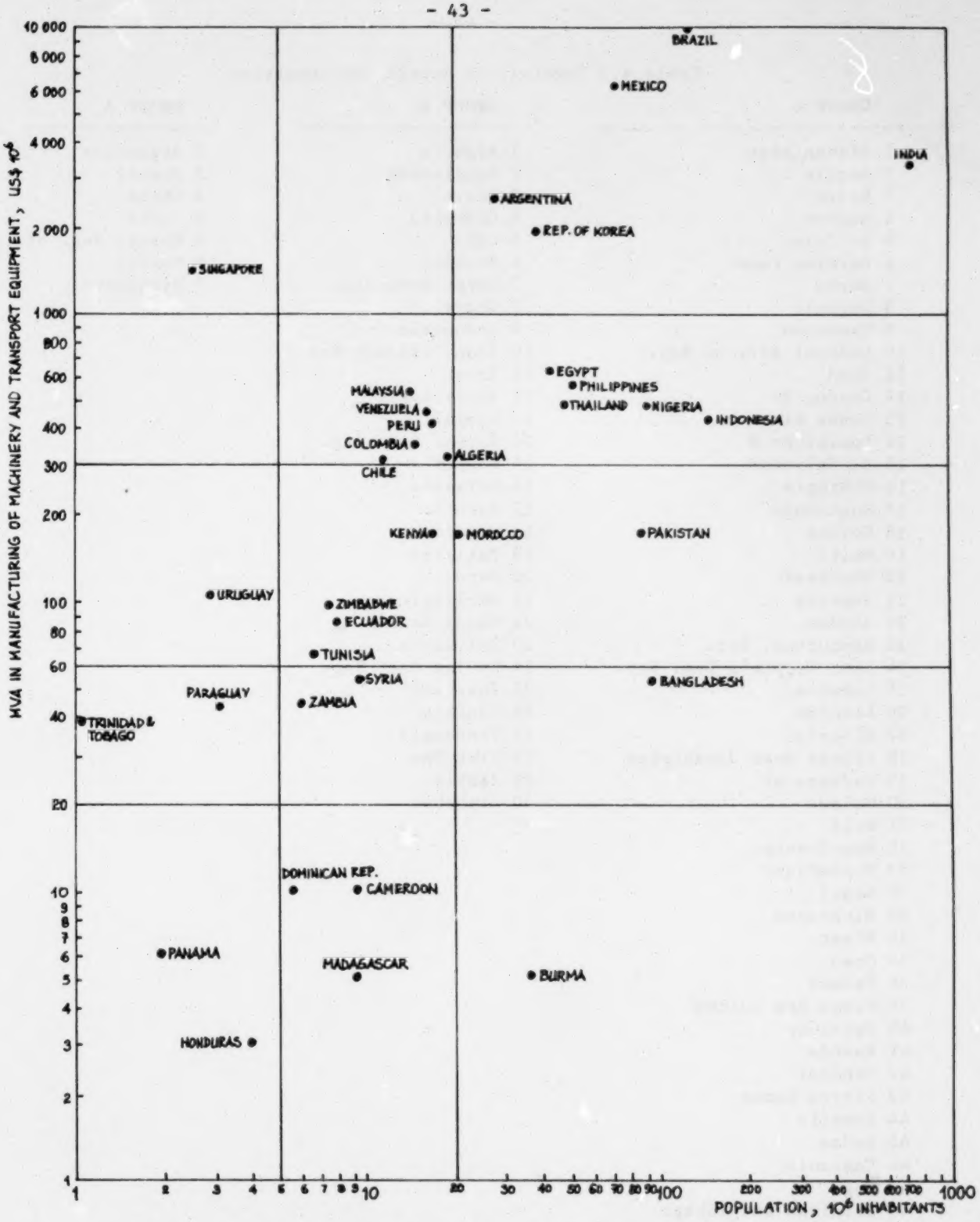

Figure 4.3 MVA in machinery and transport equipment vs. population

Table 4.3 Typology of developing countries

GROUP C	GROUP B	GROUP A
1 Afghanistan	1 Algeria	1 Argentina
2 Angola	2 Bangladesh	2 Brazil
3 Benin	3 Chile	3 China
4 Bhutan	4 Colombia	4 India
5 Bolivia	5 Cuba	5 Korea, Rep. of
6 Burkina Faso	6 Ecuador	6 Mexico
7 Burma	7 Egypt Arab Rep.	7 Singapore
8 Burundi	8 Ghana	
9 Cameroon	9 Indonesia	
10 Central African Rep.	10 Iran, Islamic Rep.	
11 Chad	11 Iraq	
12 Congo, PR	12 Ivory Coast	
13 Costa Rica	13 Kenya	
14 Dominican R	14 Korea, Dem. Rep.	
15 El Salvador	15 Kuwait	
16 Ethiopia	16 Malaysia	
17 Guatemala	17 Morocco	
18 Guinea	18 Nigeria	
19 Haiti	19 Pakistan	
20 Honduras	20 Peru	
21 Jamaica	21 Philippines	
22 Jordan	22 Saudi Arabia	
23 Kampuchea, Dem.	23 Sri Lanka	
24 Lao, People's Dem. Rep.	24 Syrian Arab Rep.	
25 Lebanon	25 Thailand	
26 Lesotho	26 Tunisia	
27 Liberia	27 Venezuela	
28 Libyan Arab Jamahiriya	28 Viet Nam	
29 Madagascar	29 Zambia	
30 Malawi	30 Zimbabwe	
31 Mali		
32 Mauritania		
33 Mozambique		
34 Nepal		
35 Nicaragua		
36 Niger		
37 Oman		
38 Panama		
39 Papua New Guinea		
40 Paraguay		
41 Rwanda		
42 Senegal		
43 Sierra Leone		
44 Somalia		
45 Sudan		
46 Tanzania		
47 Togo		
48 Trinidad and Tobago		
49 Uganda		
50 United Arab Emirates		
51 Uruguay		
52 Yemen Arab Rep.		
53 Yemen, People's Dem. Rep.		
54 Zaire		

Table 4.4 Group C countries

	Group C country	Distribution of labour force, in %, in 1980			Urban population as a % of total population, in 1982
		Agriculture	Industry	Services	
1	Afghanistan	79	8	13	17
2	Angola	59	16	25	22
3	Benin	46	16	38	15
4	Bhutan	93	2	5	4
5	Bolivia	50	24	26	45
6	Burkina Faso	82	13	5	11
7	Burma	67	10	23	28
8	Burundi	84	5	11	2
9	Cameroon	83	7	10	37
10	Central African R	88	4	8	37
11	Chad	85	7	8	19
12	Congo, PR	34	26	40	46
13	Costa Rica	29	23	48	43
14	Dominican R	49	18	33	53
15	El Salvador	50	22	28	42
16	Ethiopia	80	7	13	15
17	Guatemala	55	21	24	40
18	Guinea	82	11	7	20
19	Haiti	74	7	19	26
20	Honduras	63	20	17	37
21	Jamaica	35	19	47	48
22	Jordan	20	20	60	60
23	Kampuchea, D	..	..	..	..
24	Lao, PDR	75	6	19	14
25	Lebanon	11	27	62	77
26	Lesotho	87	4	9	13
27	Liberia	70	14	16	34
28	Libyan AJ	19	28	53	58
29	Madagascar	87	4	9	20
30	Mali	73	12	15	19
31	Malawi	86	5	9	10
32	Mauritania	69	8	23	26
33	Mozambique	66	18	16	9
34	Nepal	93	2	5	6
35	Nicaragua	39	14	47	55

Table 4.4 Group C countries (continued)

	Group C country	Distribution of labour force, in %, in 1980			Urban population as a % of total population, in 1982
		Agriculture	Industry	Services	
36	Niger	91	3	6	14
37	Oman	..	..	..	20
38	Panama	33	18	49	53
39	Papua New Guinea	82	8	10	17
40	Paraguay	49	19	32	40
41	Rwanda	91	2	7	5
42	Senegal	77	10	13	34
43	Sierra Leone	65	19	16	23
44	Somalia	82	8	10	32
45	Sudan	78	10	12	23
46	Tanzania	83	6	11	13
47	Togo	67	15	18	21
48	Trinidad and Tobago	10	39	52	22
49	Uganda	83	6	11	9
50	United Arab Emirates	..	..	..	79
51	Uruguay	11	32	57	84
52	Yemen Arab R	75	11	14	14
53	Yemen, PDR	45	15	40	38
54	Zaire	75	13	12	38

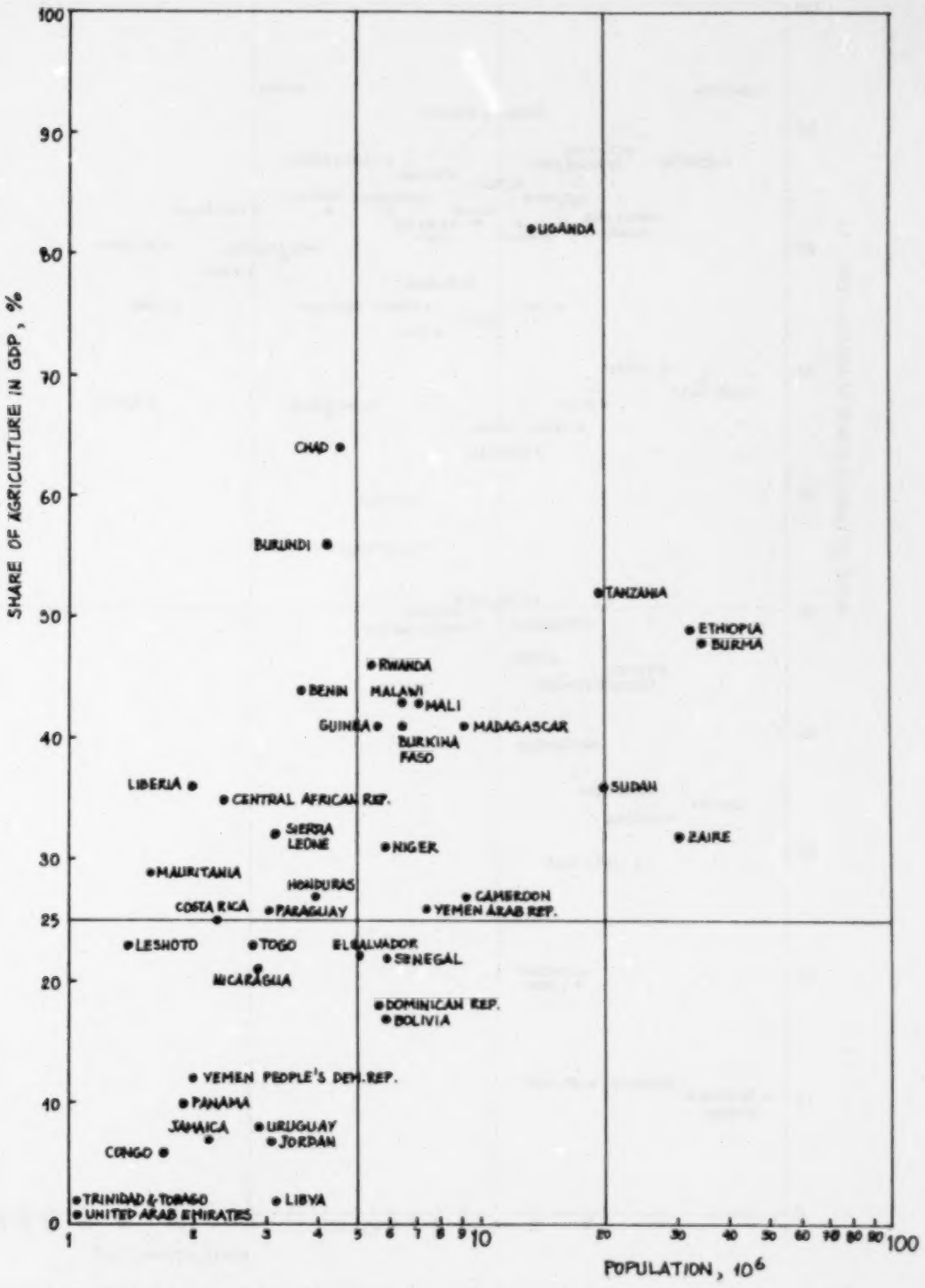

Figure 4.4 Share of agriculture in GDP vs. population

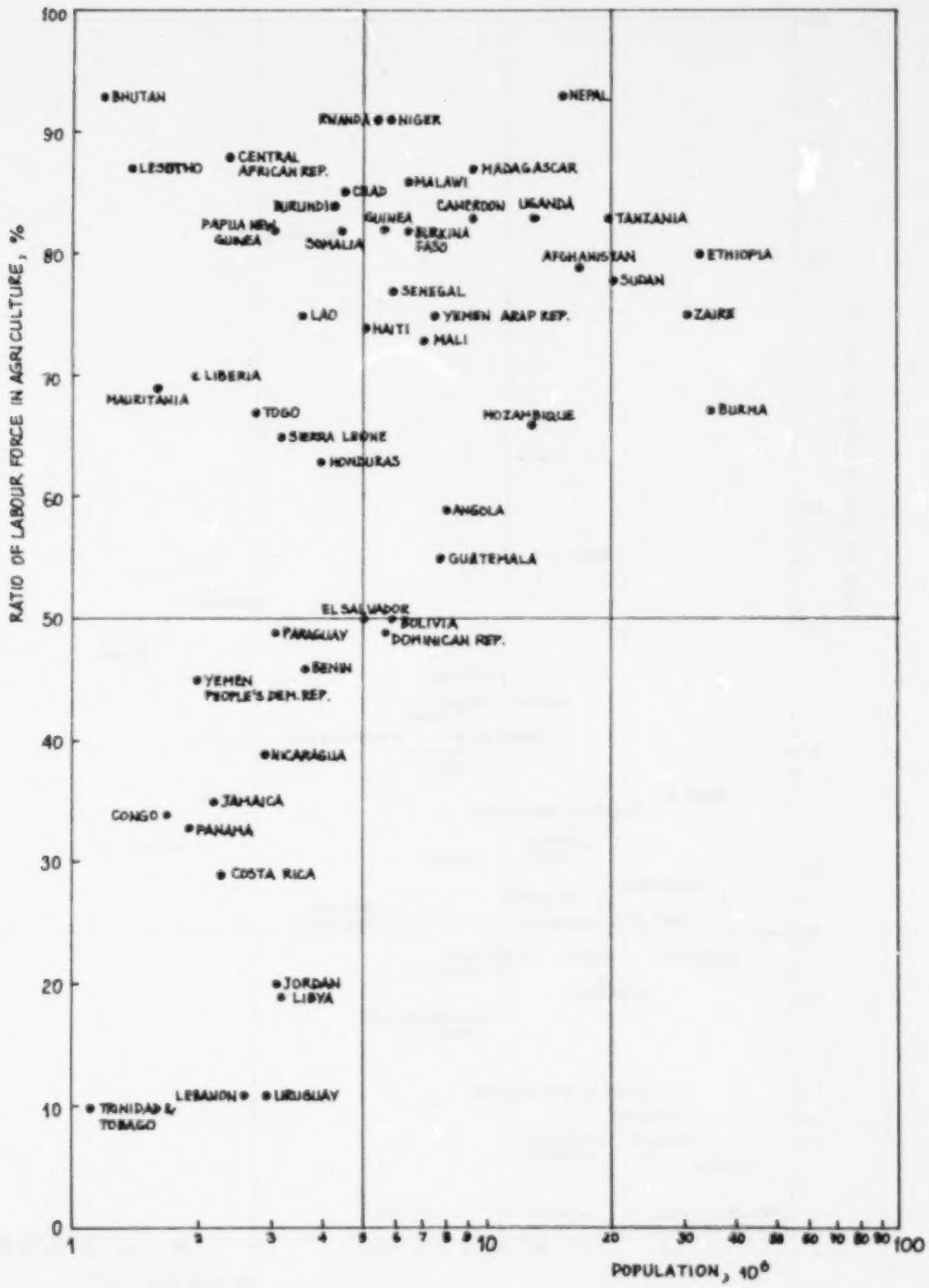

Figure 4.5 Ratio of labour force in agriculture to total labour force vs. population

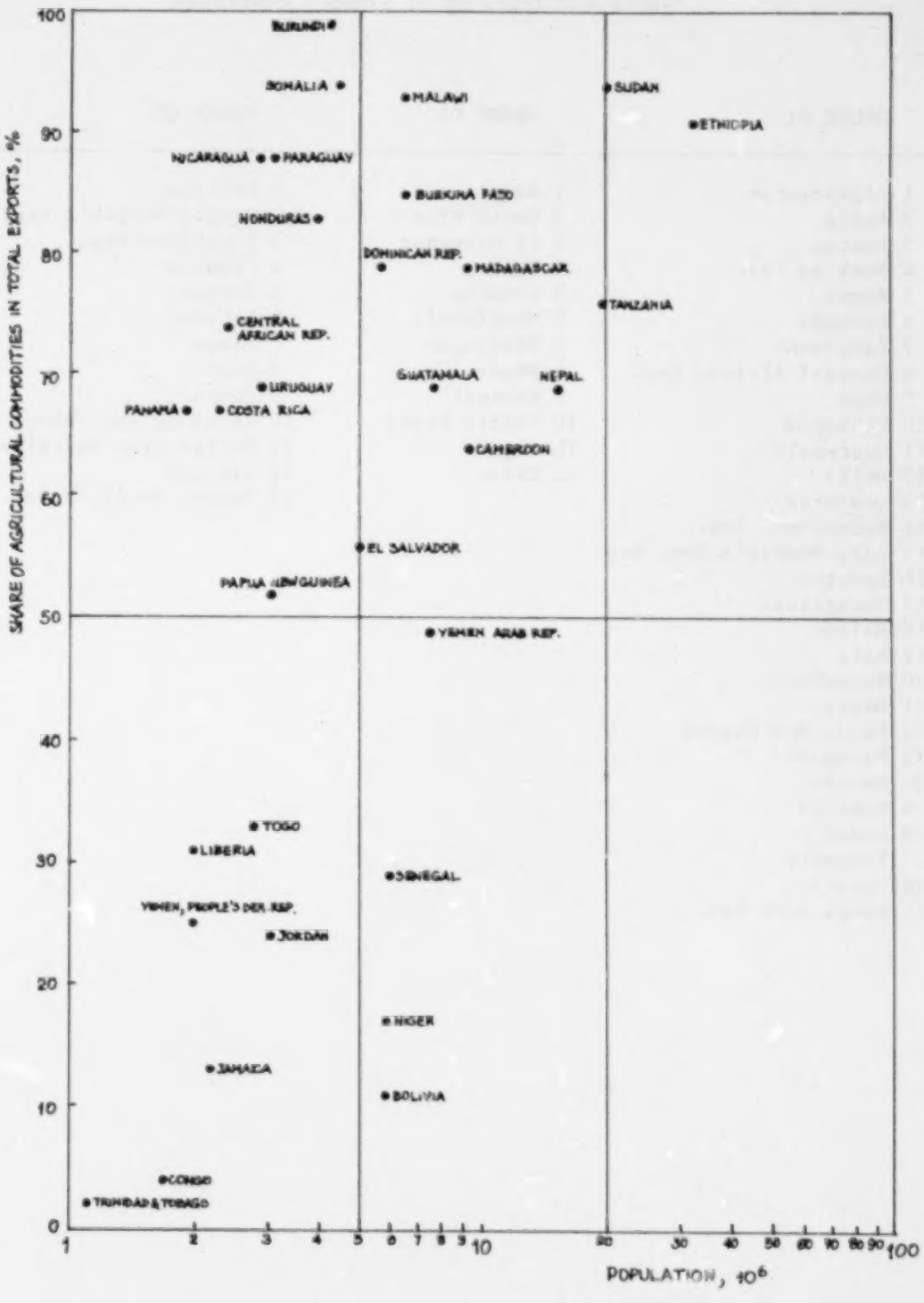

Figure 4.6 Share of agricultural commodities in total exports vs. population

Table 4.5 Typology of Group C countries

GROUP C1	GROUP C2	GROUP C3
1 Afghanistan	1 Angola	1 Bolivia
2 Benin	2 Costa Rica	2 Congo, People's Rep.
3 Bhutan	3 El Salvador	3 Dominican Rep.
4 Burkina Faso	4 Guinea	4 Jamaica
5 Burma	5 Liberia	5 Jordan
6 Burundi	6 Mauritania	6 Lebanon
7 Cameroon	7 Nicaragua	7 Libya
8 Central African Rep.	8 Niger	8 Oman
9 Chad	9 Senegal	9 Panama
10 Ethiopia	10 Sierra Leone	10 Trinidad and Tobago
11 Guatemala	11 Togo	11 United Arab Emirates
12 Haiti	12 Zaire	12 Uruguay
13 Honduras		13 Yemen, People's Dem. Rep.
14 Kampuchea, Dem.		
15 Lao, People's Dem. Rep.		
16 Lesotho		
17 Madagascar		
18 Malawi		
19 Mali		
20 Mozambique		
21 Nepal		
22 Papua New Guinea		
23 Paraguay		
24 Rwanda		
25 Somalia		
26 Sudan		
27 Tanzania		
28 Uganda		
29 Yemen Arab Rep.		

CHAPTER 5
INTEGRATED PLANNING

5.1 Introduction

60. Planning, in general, and sectoral development planning, in particular, have been treated in a large number of studies. Published material in this field reflects both the theoretical work and the results obtained from implementation of national plans in developed and developing countries [29,30,31,32,33,34].

61. Although there is a school of thought criticizing the national planning as being the cause of additional bureaucracy and inefficiency, a strong need for planning has been expressed in all UNIDO meetings on the capital goods industry. Considering the extreme self-complexity and status (i.e. the property of providing material input to all other sectors of the economy) of the capital goods industry, planning becomes a prerequisite for the national decision-making in the developing countries[35].

62. What has been attempted here is not a planning exercise but rather a development of a systematic approach and analytical tools that may assist the national planner/decision-maker. Throughout the work, the Method of Analysis

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29/ Blitzer, C.R., Clark, P.B. and Taylor, L. (eds.); Economy-wide models and development planning, World Bank, Oxford University Press, Oxford, 1975.

30/ Griffin, K.B. and Enos, J.L.; Planning Development, Addison-Wesley Publishing Company, Reading, Mass., 1970.

31/ Berri, L. Ya.; Planning a socialist economy, vols. 1 and 2, Progress Publishers, Moscow, 1977.

32/ Cohen, S.S.; Modern capitalist planning: the French model, University of California Press, Berkeley, Ca., 1977.

33/ UNIDO; Planning for capital goods industries - A new methodology, 1985, (by UNIDO Consultant M.M. Luther).

34/ UNIDO; Guidelines for industrial planning in developing countries, 1984, (by UNIDO Consultant I. Sharif).

35/ The planning issue is also referred to in Chapter 7 where the policies and strategies for the development of capital goods industry are discussed.

of Technological Complexity has been utilized. Furthermore, the field experience of UNIDO on capital goods development planning has been heavily depended upon[36/].

5.2 Integrated planning

63. The forward and backward linkages of the capital goods industry bring it to contact with almost all other sectors of the economy. This property, in turn, makes it necessary to plan the capital goods sector together with the other sectors which it links. This is the reason why integrated planning approach should be adopted.

64. An integrated plan may be developed around some basic questions:

a) What are the national economic, social, political, etc. objectives?

b) What are the capabilities already existing in the country and what are the possibilities for their consolidation and improvement?

c) What is the total future demand for capital goods, considering:

- The capital goods demand of other industrial sectors in order to reach their planned production targets and by utilizing the selected technological routes;
- The capital goods demand of other sectors of economy (i.e., agriculture, transport, services and administration);
- Production equipment demand of capital goods industry itself to manufacture the goods mentioned above, plus its own requirements for circular reproduction?

d) Can the output of the existing capital goods industry meet the total future demand of (b) above?

e) If not, what will be the additional production facilities required?

f) What will be the additional physical, technological, human, etc. inputs required by the capital goods industry to meet the total demand of (b) above?

36/ For example, UNIDO technical assistance projects on the planning of capital goods industry development in Ecuador, Colombia, Mexico, Pakistan, Turkey and Venezuela.

g) If the required inputs cannot be provided by the existing capabilities within the economy, what are the possibilities of creating new capabilities by utilizing the resources of the country?
h) If there exists a discrepancy between the required inputs and the potential capabilities of (g), what will be the strategy of selection (i.e. optimum allocation of resources)?

j) Finally, what will be the policies and strategies to be adopted in order to reach the plan targets?

5.3 Methodology

65. Outline of a proposed methodology is illustrated in Figure 5.1. As can be seen from this flow-chart, the planning activities can be divided into four blocks, namely:

I. **Diagnosis** of the present situation;

II. Estimation of the future **demand**;

III. Comparison of required **inputs with capabilities**;

IV. Formulation of **policies and strategies** when and where appropriate (decision-making).

66. There are several techniques which can be utilized in carrying out the above mentioned planning tasks. However, the methodology employed here appears to be the first attempt systematically utilizing the Analysis of Technological Complexity (ATC)[37/].

5.4 Iterative planning process

67. Estimation of total demand for capital goods, including the demand for capital goods production equipment, parts, services and components is the first step of an iterative process. The mechanism of this iteration is given in Figure 5.2.

37/ A detailed description of the methodology is available upon request from UNIDO Secretariat.

68. This process represents, for a medium-size developing country with some level of industrialization, a huge but necessary task. For a newcomer, however, the problem is more complicated since it also involves the selection of the route(s) of entry.

69. It is also quite clear that at each phase of iterative process there is an absolute need for reliable information at national and international levels.

70. Another point that must be stressed here is the time required to establish a working planning mechanism: It is a long-term undertaking and requires the creation of expert teams and/or specialized organizations. However, the earliest start would be the optimum approach.

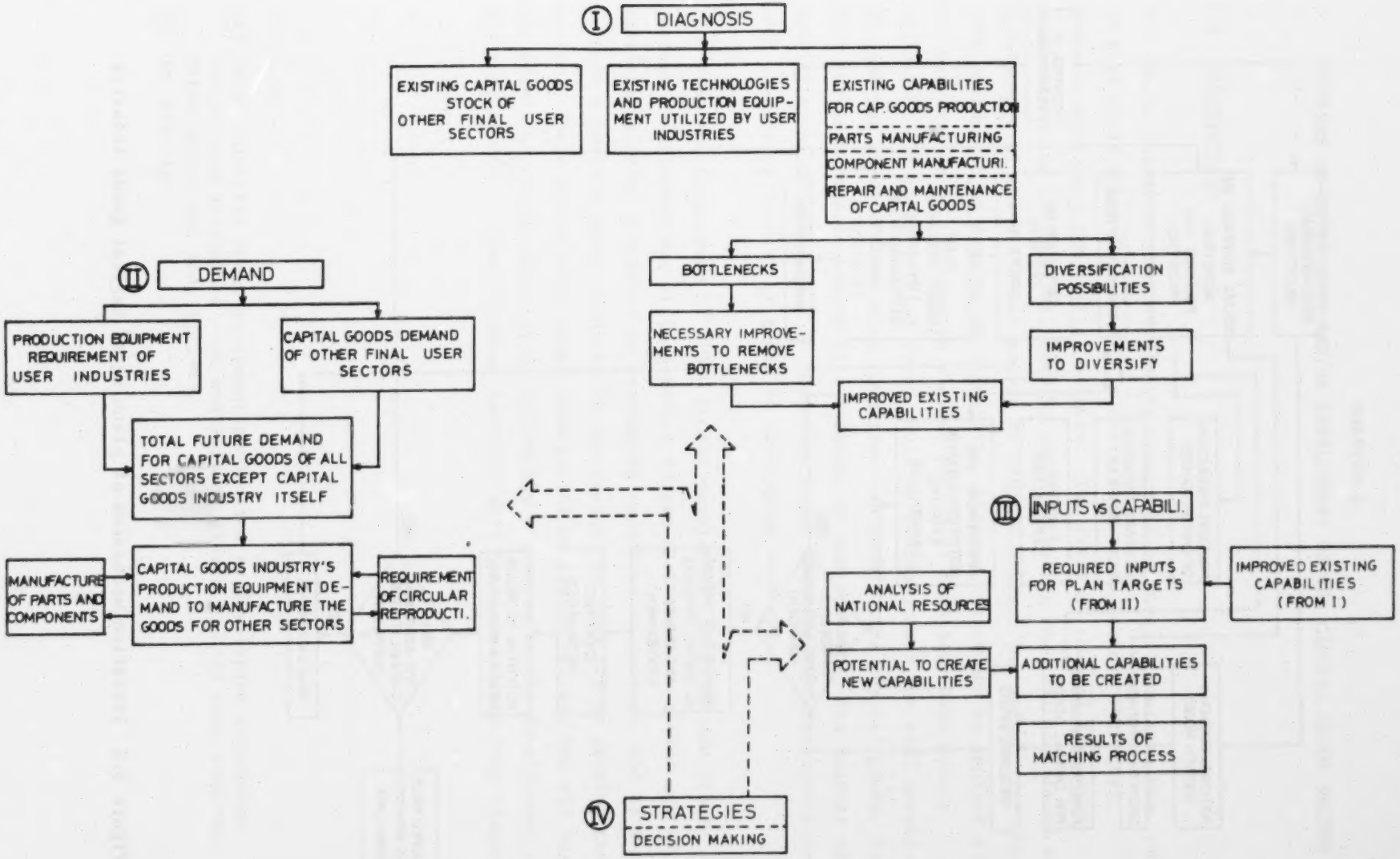
I DIAGNOSIS
EXISTING CAPITAL GOODS STOCK OF OTHER FINAL USER SECTORS
EXISTING TECHNOLOGIES AND PRODUCTION EQUIPMENT UTILIZED BY USER INDUSTRIES
EXISTING CAPABILITIES FOR CAP. GOODS PRODUCTION
PARTS MANUFACTURING
COMPONENT MANUFACTURI.
REPAIR AND MAINTENANCE OF CAPITAL GOODS
II DEMAND
PRODUCTION EQUIPMENT REQUIREMENT OF USER INDUSTRIES
CAPITAL GOODS DEMAND OF OTHER FINAL USER SECTORS
TOTAL FUTURE DEMAND FOR CAPITAL GOODS OF ALL SECTORS EXCEPT CAPITAL GOODS INDUSTRY ITSELF
MANUFACTURE OF PARTS AND COMPONENTS
CAPITAL GOODS INDUSTRY'S PRODUCTION EQUIPMENT DEMAND TO MANUFACTURE THE GOODS FOR OTHER SECTORS
REQUIREMENT OF CIRCULAR REPRODUCTI.
BOTTLENECKS
NECESSARY IMPROVEMENTS TO REMOVE BOTTLENECKS
DIVERSIFICATION POSSIBILITIES
IMPROVEMENTS TO DIVERSIFY
IMPROVED EXISTING CAPABILITIES
III INPUTS vs CAPABILI.
ANALYSIS OF NATIONAL RESOURCES
REQUIRED INPUTS FOR PLAN TARGETS (FROM II)
IMPROVED EXISTING CAPABILITIES (FROM I)
POTENTIAL TO CREATE NEW CAPABILITIES
ADDITIONAL CAPABILITIES TO BE CREATED
RESULTS OF MATCHING PROCESS
IV STRATEGIES
DECISION MAKING

Figure 5.1 National planning activities

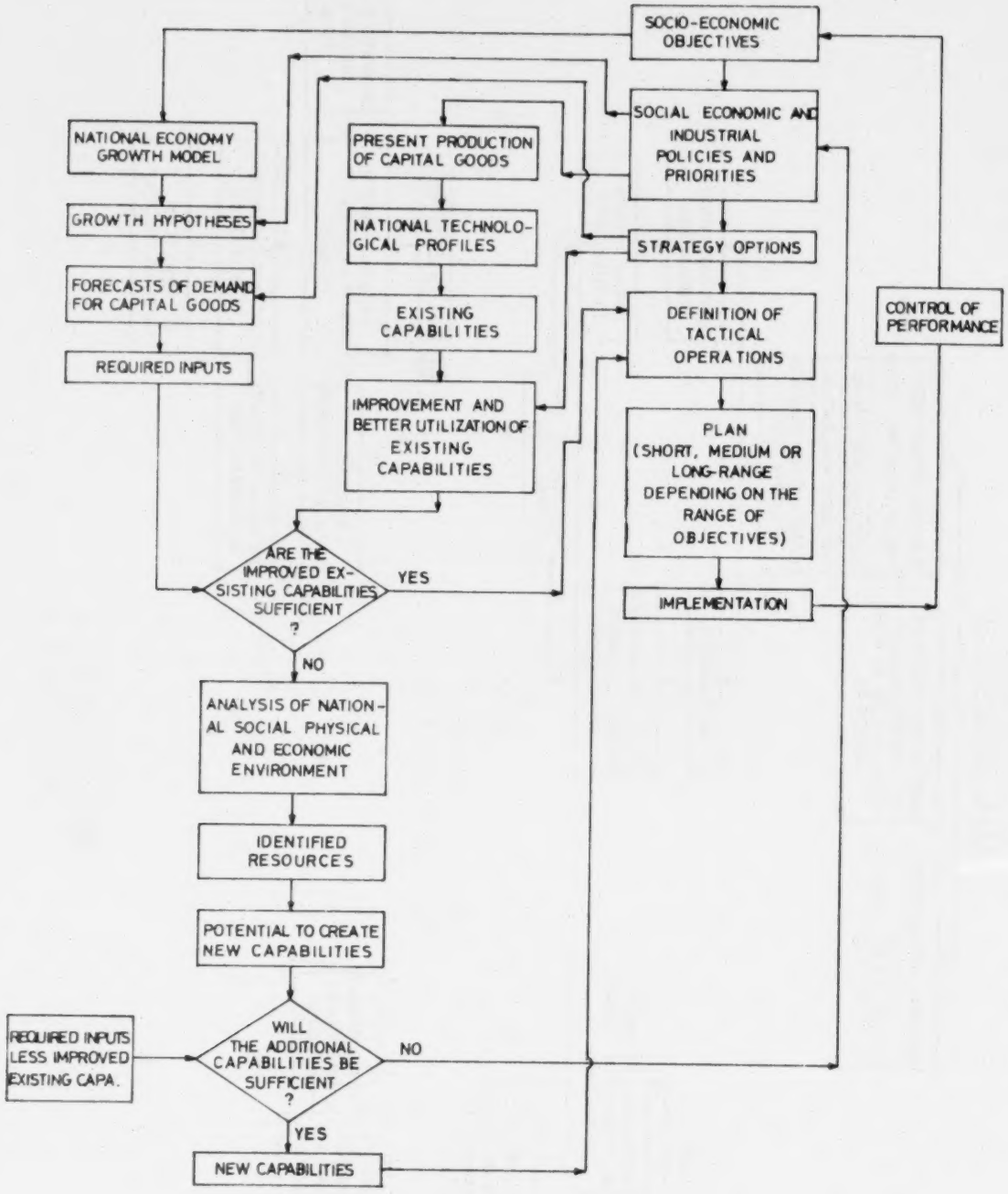

Figure 5.2 Iteration mechanism of planning of capital goods industry

CHAPTER 6

PROBLEMS OF ENTRY INTO AND/OR DEVELOPMENT OF THE CAPITAL GOODS SECTOR

6.1 Introduction

71. It is essential that developing countries produce a growing number of the capital goods which they need. In their efforts to achieve this goal, however, they face two initial dangers: The first is that of frequently underestimating the possibilities by misinterpreting the real conditions of manufacture of the different groups of capital goods. The second, for the same reason, is of drawing up unrealistic plans which cannot be applied since the barriers to be overcome in a given period of time have been poorly evaluated. If these initial traps could be avoided, then the real question becomes not whether developing countries can manufacture capital goods, but what they can produce taking into account, on the one hand, the degrees of complexity of machines and, on the other hand, the specific characteristics of each developing country or group of developing countries.

72. From the experience of UNIDO in the developing countries and other sources of information, it is possible to see that there is a wide set of constraints which are faced by developing countries in general, and by those without a capital goods industry in particular, as they try to develop this sector. These constraints range from social to technological, but all have the effect of either directly or indirectly discouraging the development of the sector[38,39/]. Some of these barriers will be discussed in this chapter.

38/ UNIDO; Electric power equipment production in developing countries: Options and strategies - An analysis of eleven country case studies, UNIDO/IS.507 and Add. 1, 1985.

39/ Op. cit. 14/.

6.2 Demographic constraints

73. The constraint over which the individual countries has the least control is that of the skills pool with which to develop the capital goods sector. Training of skilled or semi-skilled manpower takes time and as a result can not be solved immediately even if financial resources and/or legislative framework is available. The demographic constraint appears in two forms, macro and micro.

74. At the macro level, there is a requirement for sufficient skills within the economy to support the manufacturing sector broadly and to support the background skills required in capital goods industry. The skills required come in several different forms such as manual skills, technical skills, managerial and accounting skills, some level of literacy in the work force, skills at sales and marketing, etc. These skills form the core of what might be called an **industrial tradition**, something considered to be essential for the founding of anything more than rudimentary manufacturing operations.

75. Skills at the micro level are required for any industry in a country in general, and for the establishment of specific industries in particular[40/]. For example, there is a need for personnel trained in specific areas of machine design for the establishment of machine tool manufacturing firms. Training of specialized personnel goes far beyond the organized educational process. There is much on-the-job training of engineers and production people. The skills that are developed and passed on in on-the-job or plant specific training constitute a large fraction of the technology possessed by the manufacturing company, and these are among the hardest parts of the technology for a developing country to acquire.

76. The availability of trained personnel is always at issue but those countries which have been able to accelerate the training process at both the macro and micro levels have been the most successful at advancing the capital goods sector.

40/ Op. cit. 16/.

6.3 Capital constraints

77. Within all of the developing countries it is lack of capital that is argued to have the single largest impact on development of all of the manufacturing sectors in general, and capital goods industry in particular. This capital starvation is clearly seen in the least developed countries (LDCs) where all sectors of economy compete heavily for scarce local and foreign funds. Again this constraint takes a set of forms for the capital goods sector: Macro constraints, micro constraints and market constraints.

78. At the **macro level**, virtually all developing countries are heavily dependent upon foreign borrowing. The impact of this borrowing is that for the capital goods industry as well as for other manufacturing sectors there is a limited availability of foreign exchange which makes up an increasingly large component of the capital requirement as one proceeds along the path of development of the sector. The effect is one of competition for the capital. The competition is among all sectors and includes the human services sectors of health and education as well as the industrial sectors. As a result, governmental structure has a significant effect on who is allocated how much, and what the relative emphasis will be.

79. At the **micro level** the capital constraints are probably the most severe for the capital goods of higher technological complexity than for some of the other manufacturing sectors. Technologies are imported, the importation requires licenses or partnerships that themselves must be capitalized on a one at a time basis. These licenses must be renewed and new licenses sought when technologies evolve otherwise facilities are producing obsolete equipment. Furthermore, those raw materials, intermediate goods and components which are not locally produced should also be imported. Providing the constant stream of capital may be difficult particularly if the market size is not sufficient to support a profitable industry.

6.4 Market size constraint

80. As has been foreshadowed above, the size of the market can and does play

a major role in the ability of a country to establish successful production units of the capital goods industry. Market size has three separate components to it, domestic demand, export demand (both open market and common market) and timing.

81. Focusing only on the internal demand for equipment, the manufacture of capital goods of technological complexity levels I, II and (partially) III are generally supportable from domestic demand alone (and frequently not extensively traded on the international markets). Both of levels I and II goods can be produced mostly from indigenous raw materials and/or indigenous intermediate goods. In neither of these levels is the capital requirement dedicated to only one type of equipment (see Chapter 3 and 8). Clearly, the case is the same with products requiring the similar processes such as cutting, bending, welding or punching of metals. The capital goods of lower technological complexity do not require a major market because the capital and skills themselves are not unique and can, therefore, be adopted to another application if, either permanently or temporarily, the market evaporates (see Chapter 8 and 9).

82. Development of capital goods industries to manufacture goods of complexity levels IV, V and VI requires considerably more attention to market size as in all of these areas the production unit is more or less dedicated to specialized production. For these goods the size of the domestic market and the critical size of the production units play a major role in defining the level of sectoral development[41/].

83. Development of an international market for capital goods is done in one of two fashions, either through active export promotion in a free market environment or through some forms of limited trade in common market structures. The development of free market exports is a goal of several developing countries but has been implemented in only a limited number.

41/ Op. cit. 15/.

84. A second area of interest in development of export markets is the potential for a regional market. It is possible in a common market type of structure to have the market be the size of two or more countries and as a result have each country specializing in some type of capital goods. This theoretically attractive alternative appears not to be poltically or administratively feasible under many circumstances, though one might argue it is the only way in which some of the developing countries will be able to enter into the higher technological complexity levels.

85. The final issue in market size is that of timing. No industry can exist in an environment of dramatic peaks and troughs. Even though there may be a large demand for particular types of capital goods, the fact that the demand is directly associated with specific projects which are constructed only once every ten years is not sufficient to allow for the market to mature and therefore for an industry to develop which manufactures that equipment (see Chapter 8).

6.5 Perceptual constraints

86. One of the most interesting and least well understood of the constraint sets identified is one would be labeled as perceptual. The existence of such constraints may be felt from the following:

a) There appears to be a prejudice in favour of capital goods purchased from the suppliers in industrialized countries. This prejudice can be expressed in several ways ranging from quality and testing requirements to financing of purchases.

b) There is an unnecessary mystification of capital goods and their manufacture. The very large number and widely varying technological complexity levels of products and manufacturing processes are the main reasons of this mystification, and it frequently results in either abandonment of the idea of local manufacture or transfer of unsuitable and/or unnecessary technologies.

87. Eliminating the cynical explanation, one may argue that the first perceptual constraint is due to a combination of habit, training, and lack of technical and technological know-how. Habit, because a supplier has always been the supplier and there is a desire not to try to understand or develop

new product specification. Training, because in many countries it is very probable that the high level technical personnel in charge of product specification and purchasing have been trained in one of the developed countries. The result is that they have learned how to select equipment along specific lines. They adopt the same standards and use the same information as the manufacturers of the countries in which they did their training.

88. Sometimes more influencial than habit or training is the lack of technical and technological know-how. Because of this deficiency, the purchaser prefers to accept the specifications of the established firms rather than to control the quality and carry out testing of the domestic products. The situation is aggravated when testing and quality control installations are not available in country. It is interesting to note that such installations can never be created if the domestic production does not exist.

89. Mystification of capital goods and their manufacture is probably the most dangerous and pessimistic approach. UNIDO has identified this constraint while preparing for the First Consultation and several studies were carried out to bring some transparency to it[42/]. Among others, the methodology of Analysis of Technological Complexity (ATC) has been devised to decipher the conditions of manufacture of different capital goods. The analytical results and field applications have revealed that there is scope for many developing countries to start and sustain a capital goods industry provided that products and technologies are selected according to the realities of the country and every effort is made to remove those barriers which apply to each specific case.

6.6 Financing constraints

90. Project packages and financing arrangements in connection with the capital goods industries of developing countries do not always attach atmost

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42/ - Op. cit. 13/.
- Op. cit. 14/.

importance to the issues such as mastery of technology and rapid indigenization, training, product and process adoptation, etc. which are vital for the industrialization of developing countries.

91. The influence of financing agencies on the structural formation of the capital goods industry in a developing country is greater in the case of projects involving the manufacture of complexity level IV and higher products. Numerous examples of facilities which turned out to be a mere assembly line using CKD kits indicate that negative impact.

6.7 Other constraints

92. Access to technology also appears to be a constraint, especially when high technologies are sought for transfer. This barrier, theoretically, does not exist at the low technology end. However, its impact is also felt there due to inability of small- and medium-scale enterprises to reach the international technology market.

93. Economic and technical infrastructure are vital to the development of the capital goods industry. Efficient and economical means of transport, communications, water and energy delivery are all important. Basic technical services such as casting, forging, heat treatment, manufacturing of jigs and fixtures, etc. constitute the technical infrastructure required to develop even the simplest capital goods industry. Although there are some techniques to reduce the dependence on, for example, casting and forging by using techniques such as cut-and-weld, they are limited and the establishment of basic technical services should be given highest priority.

94. Supply of raw materials and intermediate goods is another critical factor. In particular, availability of iron and steel products can be decisive in whether a capital goods industry can be sustained or not. In the case of simple capital goods steel constitutes the major portion of weight and, quite often, of cost. In many developing countries, there is a close correlation between the domestic production of iron and steel and the development of the capital goods industry.

6.8 Government action

95. The final constraint to establishment or development of the capital goods industry is the actions of the Government. These actions may take a number of forms; purchasing policies, incentives, currency valuation, tariff policies, instability of policies, etc.

96. Under most circumstances, the Government of a developing country is a major purchaser of capital goods. The purchasing policies of the Government, therefore, can promote or hinder the development of the domestic capital goods industry, depending upon whether they are systematically biased toward the domestic products or not.

97. Government incentives, both to manufacturers and purchasers of the final products can be very effective for the development of the capital goods industry. In particular, financial support to farmers for purchasing agricultural machinery and rural equipment is required not only to develop the agricultural machinery industry, but also to increase the agricultural productivity (see Chapter 9).

98. Under most circumstances the undervaluation of a currency may tend to assist in the development of an indigenous supply sector such as capital goods. It is interesting to note that the undervaluation may have a mixed effect. If the capital goods sector is heavily involved in an export business then the undervaluation will have a positive effect --it will make the products relatively less expensive and therefore more competitive. If the sector produces entirely for the domestic market the impact may be less easy to predict. On the one hand, it will be substituting for relatively more expensive imported goods, but at the same time the manufacturer may see that his best capital decision will be not to manufacture for the local market but rather to manufacture for the export market (an entirely different product) and thereby utilize a scarce resource --capital-- and undervalued labour to either establish a niche in the internationl market or simply to export the undervalued labour as a part of the cost of manufactured product. The result under these circumstances would be biased against the capital goods industry.

99. In much the same manner the tariff policy of a government, even one designed to protect infant industries, may bias in favour of industry aimed at export rather than only a local market. This despises the avowed intent of the tariff.

100. The final constraint that governments may introduce in the system is probably best seen in countries where the government policies change frequently. The effect of the changes in government policies, on the one hand, can directly (and in many cases negatively) affect the state enterprises and, on the hand, may be perceived by the local investor as an environment in which his capital is at risk and one in which only investments that will yield a rapid return are worth the risk. It should be remembered that much of the capital goods industry is not one that lends itself to quick profits, but rather to high capital investments and therefore to longer term paybacks.

6.9 Summary

101. The brief analysis of constraints given above was not made to draw a pessimistic picture. On the contrary, it was made to demonstrate that possibilities exist for developing countries to enter into the capital goods sector and to develop it provided that certain commitments are made and policies and strategies are followed. Furthermore, the constraints that have been identified are both real and perceived, are both economic/financial and governmental. As a result, dealing with these constraints once recognized will require action on a case by case basis.

CHAPTER 7
POLICIES AND STRATEGIES

7.1 Introduction

102. The studies carried out for the First Consultation on the Capital Goods Industry and additional work done for the Second Consultation have clearly shown that the development of the capital goods industry in a developing country requires complete dedication and demonstration of will on the part of the Government. Without relevant Government action based on clearly stated and concretely implemented political decisions, no capital goods industry, in the real sense, can be established. This statement holds irrespective of the economic and political system of the developing country.

103. The development of capital goods industry should be linked with the goals of economic development of a developing country. Goals may differ at different stages of development and from country to country (see Chapter 4). Some of the possible orientations could be the following:

- The development of agriculture and agro-based industries to ensure food for the population and to implement rural development programmes (Group C countries in general, and Sub-group C1 and C2 countries in particular --see Chapter 4);
- Development of those specific sub-sectors of the capital goods industry which would manufacture equipment for the dominant sector(s) of the economy (e.g., mining, textiles, etc.);
- Import substitution being adopted as the main industrial target;
- Predominantly export oriented industrial development including capital goods industry (some of the Group A countries --see Chapter 4);
- Creation of a technical infrastructure as a prerequisite for a stable development with relatively high rates of growth and specialization in capital goods industry.

104. An attempt to formulate a strategy to develop a capital goods industry according to the groups of countries had been made while preparing for the First Consultation 43/. Here, the attention is focussed on the problems of

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43/ Op. cit. 14/.

entry. Therefore, the discussion will be limited to the development of a strategy for those countries which have a very low industrial base (i.e., Group C countries --see Chapter 4).

7.2 Role of the Government

105. The development of the capital goods industry is not a spantenous phenomenon. Although a certain number of mechanical capacities manufacturing simple tools and equipment or carrying out repair and maintenance work appear in every country under the impulse of artisans or small-scale private industrialists, creation of larger enterprises to manufacture more complex equipment, in most of the cases, may necessitate the intervention of the Government.

106. The role of the Government can be summarized as to establish the economic and industrial environment which is necessary for the development of capital goods industries. In this sense, the action of the Government concerns various fields relating to:

- The planning of capital goods industry;
- The organized education and training of industrial manpower;
- Financing;
- The development of engineering, technical support and research and development capabilities;
- Creation and development of production units;
- Regional co-operation.

107. The special features of capital goods industry and its backward and forward linkages with other sectors of the national economy make it necessary to develop a medium-and long-term national plan as well as a specific capital goods development plan. In order to contribute to harmonious development and the integration of the national economy and to the achievement of the socio-economic goals, the capital goods industry should be an integral part of the medium- and long-term national plan. Planning along these lines should contribute to the implementation of national and sectoral strategies, determine development priorities, optimal allocation of resources including capital goods industry, development of technical infrastructure, technical education, financing, research and development.

7.3 Common strategies for Group C countries

108. In the countries of Group C, the main problem is to identify the route of entry into the capital goods industry. In this regard, two approaches may be applicable (see Chapter 4):

a) The satisfaction of fundamental needs such as food production, building construction, infrastructure, etc;

b) The development of national resources such as mining, mineral processing, etc. and/or the promotion of traditionally strong sectors such as textiles, leather, wood and wood products, etc.

109. In both approaches, the estimation of medium-and long-term demand (or the determination of types and quantities of required capital goods) is the starting point. This activity answers one of the fundamental questions "What should be produced?".

110. The second stage is the selection of technological production route which would answer the other fundamental question "How should it be produced?". Here, again, two approaches are possible:

a) Implementing projects linked to a product or to a range of identical products (such as the manufacture of a limited range of agricultural machinery, food processing equipment, mining structures and machinery, etc.);

b) Implementing projects depending on the common dominant characteristics of the capital goods industry (such as production machinery, processes, technical services --casting, forging, etc.) and manufacturing those products which are required by different end-user sectors but may be produced within same facility (multipurpose production --see Chapter 8).

111. It will be shown in Chapter 8 that, provided that the necessary precautions are taken, the second approach may be effective to remove some of the barriers which exist in Group C countries. This approach, however, leads to three consequences:

a) The importance of repair and maintenance as a way of entry and a possibility of training skilled labour;

b) The organization of the production units which would involve decentralized multipurpose units of low specialization;

c) The transfer of technology which, for the capital goods of low technological complexity, would relate to product designs and mastery of processes and, in some cases, to adoption of product designs and processes to the local conditions.

112. In Group C countries in general and, purely agricultural Sub-group C1 countries in particular, the Government should participate in all phases of the production of capital goods. The following is a non-exhaustive list of important stages in the process of capital goods production in which the intervention and/or assistance of the Government are required:

a) Studies relating to the selection of products and production routes to meet the fundamental needs; sectoral and national planning and plan implementation;

b) The survey of domestic technical capabilities;

c) The organization of repair and maintenance network for the existing capital goods;

d) The establishment of research and development, engineering, testing and standardization services;

e) Organized education and technical training of the industrial manpower;

f) Establishment of financing institutions to promote the domestic industry (both at the supplier and purchaser sides);

g) Arrangements for international transfers of technology and financing;

h) Sub-regional and regional co-operation arrangements.

CHAPTER 8
MULTIPURPOSE PRODUCTION APPROACH [44,45]

8.1 Introduction

113. In the preceeding chapters it was argued that a set of barriers hinders the entry into and/or development of the capital goods industry in developing countries. Even when most of the barriers are removed by mobilizing immense efforts, those obstacles which are dependent on the size of the market, and the critical size of the production units necessary to ensure economical production runs and volumes as well as to sustain the annual rate of technological innovation would remain. The existance of these techno-economical barriers makes it difficult or even impossible for the developing countries to adopt the same production models as the industrialized countries. This statement is particularly true in the case of small developing countries which have no or only an embryonic capital goods industry (see Chapter 4).

114. It is, therefore, necessary to find other structural formulas which are capable of dynamizing and proliferating the activity of capital goods industry in developing countries. One such formula would be the multipurpose production approach[46,47]. Multipurpose production unit has the purpose of

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44/ This chapter is mainly based on the study carried out by UNIDO Consultant F. Vidossich; "Multipurpose production units: Theoretical considerations and practical applications, 1984".

45/ Application of this approach utilizing the ATC methodology has succesfully been tried within the UNIDO technical assistance project: "Développement de la méthodologie d'Analyse de la complexité Technologique pour les biens d'équipement en Tunisie", UF/TUN/84/216, 1984 (op. cit. 18/).

46/ UNIDO; Report of the Second Consultation on the Agricultural Machinery Industry, ID/307, 1983.

47/ UNIDO; Report of the Expert Group Meeting on the Development of Multipurpose Agricultural Machinery Plants, Guangzhou, P.R. China, 13-18 November 1984.

replacing the production runs and volume of production characteristics of specialized companies, which are almost always incompatible with the markets of developing countries, by manufacturing in small batches of a limited variety of capital goods.

8.2 Multipurpose production

115. The multipurpose production route appears to be attractive from every point of view, particularly as it seems to be difficult to envisage other valid structural alternatives. However, if the multipurpose units are to be able to maximize their advantages for the developing countries in general, and newcomers in particular, they must be designed and operated according to very precise rules.

116. It is clear that the flexibility of production increases as soon as one moves from a combination of series production and specialization to multipurpose units. Through these units, a first objective for the developing countries would be achieved; making possible production activities that would otherwise be postponed indefinitely. But multipurpose units must be designed and operated in such a way that it is possible for developing countries to accumulate technological knowledge. This goal, namely the mastery of technologies, is equally important and cannot be abandoned.

117. To guarantee this accumulation process, an endeavour should be made to establish industrial configurations capable of defining precisely the fields of action of the various types of multipurpose units.

118. When the production pattern of market economy developed countries is analyzed, it can be seen that some forms of multipurpose production already exist. As a starting step, therefore, it should be ascertained whether they are applicable to the developing countries.

119. It would be wrong to associate multipurpose production with the following:

a) **Random production** which assumes that it is sufficient to have a certain stock of machine tools so varied that they can do almost everything;

b) **Assembly or semi-assembly** with no or very limited indigenization of a wide variety of products would not permit accumulation of technological knowledge and should not be regarded as a multipurpose operation;

c) **Flexible manufacturing systems (FMS)**, while providing the highest level of flexibility they require very capital intensive investment and very high level operating skills (including, for example, CAD/CAM --Computer Aided Design/Computer Aided Manufacturing techniques). These characteristics make FMS unsuitable for most applications in developing countries.

120. It is, therefore, desirable to observe and interpret what has already been done in some developing countries in the last decades in order to decide on the criteria for the composition of multipurpose production units (MPUs). The point of departure for creation of MPUs in developing countries has always been to benefit from the versatility of manufacturing in small batches and utilizing the minimum acceptable critical unit size rather than high degree of specialization, large production runs and large facilities.

8.3 Types of multipurpose production units (MPUs)

121. The various products to be manufactured in a MPU must have some common dominant characteristics (or homogenous characteristics), in which context the nature of the production equipment is not the sole factor to be taken into consideration.

122. In order MPUs contribute to or take part in the industrialization efforts of a developing country the following should be observed:

a) In a developing country, MPUs cannot operate at a higher technological complexity level than the rest of the capital goods industry. If the products of higher complexity levels are selected then the MPU is forced into a mere assembly or semi-assembly operation in which accumulation of technological knowledge is not possible;

b) If (a) is observed then all castings, forgings, etc. (sub-block B1 operations --see Chapter 3) must be made in the country;

c) Furthermore, technical services rendered by the third parties, such as heat treatment, tooling, manufacturing jigs and fixtures, moulds, dies, etc. (sub-block B2 operations --see Chapter 3) must be of local origin, if not completely, at least to a very large extent.

123. Within the principles set above, and considering the common manufacturing characteristics of products, eleven types of MPUs have been identified. They are further grouped into three:

a) MPUs whose common dominant characteristic is the production equipment and processes (sub-block A3: Factors of production --see Chapter 3);

b) MPUs that are homogenous in terms of the level of some well defined factors (sub-blocks A1 and A2 --see Chapter 3);

c) A variety of specific cases reflecting or belonging to very different situations.

124. The three groups and eleven types of MPUs identified are the following:

a) **GROUP I : Production equipment and processes**

- MPU 1 : Metal forming machine tools
- MPU 2 : Chip removing machine tools
- MPU 3 : Metal forming and chip removing machine tools
- MPU 4 : Manufacturing processes

B) **GROUP II: Level of some production factors**

- MPU 5 : Precision and/or quality
- MPU 6 : Hours of direct manufacturing labour per ton of finished product (H_d)
- MPU 7 : Hours of work in the design office per US$ 1,000 of finished product (H_s)

c) **GROUP III: Miscellaneous**

- MPU 8 : End-user sector of the finished products
- MPU 9 : Common-user sectors of the finished products
- MPU 10: Hi-tech equipment requiring large-scale human and physical resources and financing
- MPU 11: Repair and maintenance of equipment and systems

125. Table 8.1 shows the eleven types of multipurpose production units (MPUs). In this table, for each MPU, common dominant characteristic, technical infrastructure and component requirements, technological complexity levels of final products and possible areas of application are given.

126. Figure 8.1, on the other hand, shows the eleven MPUs identified as well as the most important linkages between them. This figure demonstrates that although there must always be a common dominant characteristic in each MPU, it does not mean that there may not be some degree of coincidence with other MPUs among the remaining ten.

Table 8.1 Types of multipurpose production units (MPUs)

MPU	Common dominant characteristic	Technical infrastructure requirements	Component requirements	Possible complexity level of products N1 N2 N3 N4 N5 N6	Examples
GROUP I: Production equipment and processes					
1	Metal forming machine tools	Low	Low	o o o o	Boilermaking without machining (except drilling), simple agricultural machinery, metal structures, vehicle bodywork, etc.
2	Chip removing machine tools	Medium-high	Low-medium	o o o o o	Machines, machined parts, sub-assemblies
3	Metal forming and chip removing machine tools (1+2)	Medium-high	Medium-high	o o o o o o	Machines in general
4	Manufacturing processes	High-very high	-	o o o	Electrodeposition, surface protection, painting, heat treatment, stress relieving
GROUP II: Level of some production factors					
5	Precision and/or quality	High	High	o o o	Measurement and control instruments, dies for cold stamping, moulds for plastics
6	Hours of direct manufacturing labour per ton of finished product (H_d)	Low	Low	o o o o	Machines in general
7	Hours of work in the design office per US$ 1000 of finished product (H_s)	Low	High	o o o o	Furnaces, food processing equipment, etc.
GROUP III: Miscellaneous					
8	End-user sector of the finished product	-	Medium-high	o o o	Hospital equipment, automotive service station equipment, bakery equipment, etc.
9	Common-user sectors of the finished product	-	High	o o o	Components and sub-assemblies for hydraulic, pneumatic, lubrication, vacuum, electric and electronic circuits and systems, optical components
10	Hi-tech equipment	-	Very high	o o	Aeronautical, physical research, avionics, etc. equipment and systems, space vehicles and rockets, etc.
11	Repair and maintenance of equipment and systems	-	-	o o o	Maintenance of transport equipment, electric power equipment, compressors, pumps, etc.

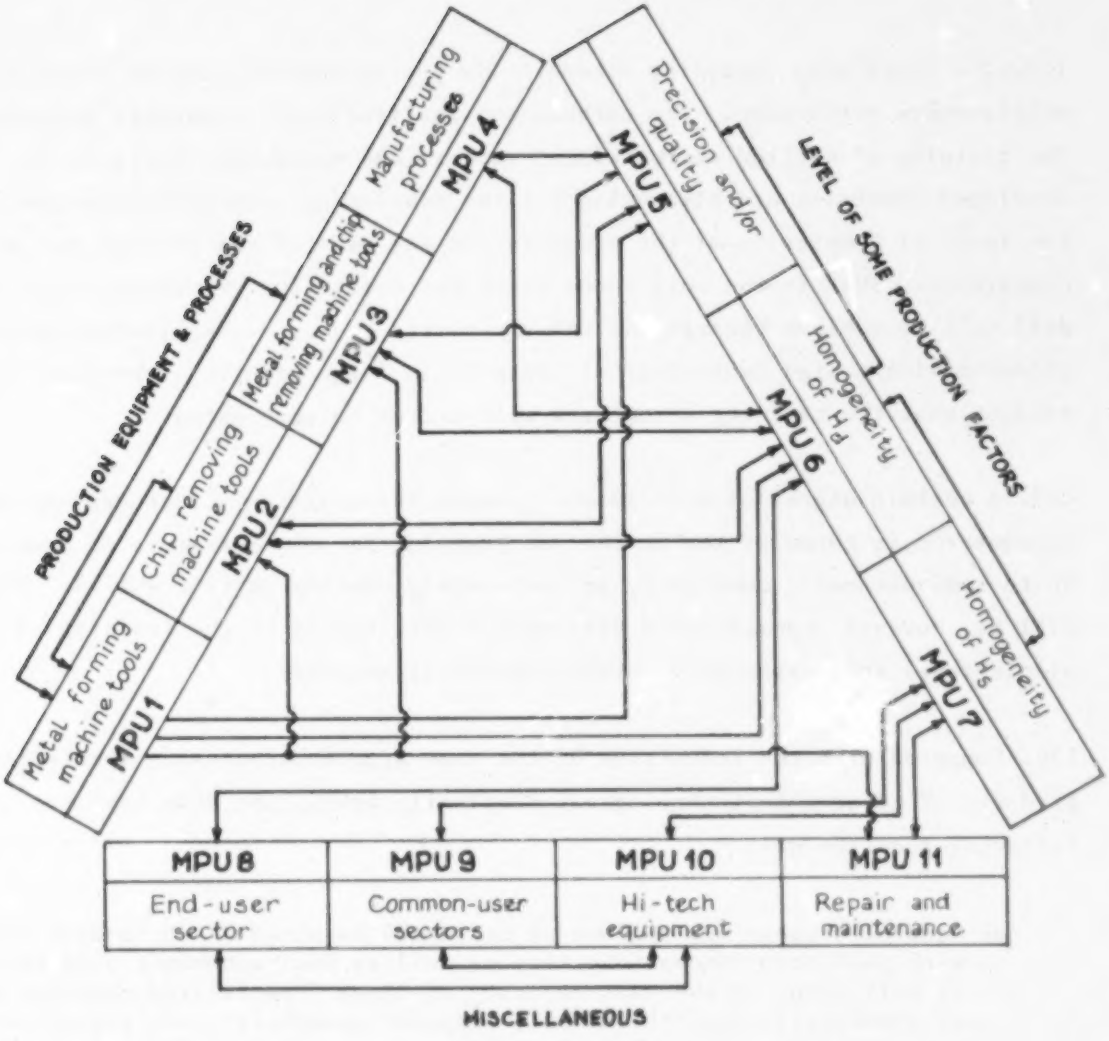


Figure 8.1 Interactions between the common dominant elements of MPUs

8.4 Special problems of multipurpose production

127. If the large-scale application of multipurpose production is considered in a developing country, then the special problems caused by their presence in the capital goods industry should be pointed out and analyzed.

128. The first area requiring attention is the increased training needs of multipurpose production. The methods and institutional frameworks adopted for the training of skilled and unskilled workers and management staff in the developed countries are also valid for the developing countries, provided that the level of complexity of the products and the size of the enterprises are comparable. That is the only sound basis for comparison. However, that is difficult to achieve because the industrialized countries manufacture mainly products with a high technological content, in large plants. Therefore it is evident that the training structures will differ to some extent.

129. A certain degree of coincidence between the training structures may be encountered in terms of the on-the-job training for the operators of machines up to semi-automatic complexity and moderately complex setting skills. There will be, however, considerable differences with regard to the training of middle-level and, especially, higher technical managers.

130. Compared with the industries of the same size manufacturing specialized products of comparable technological complexity level, the MPUs have the following requirements:

a) Generally speaking, the use of universal machines of up-to-date design with good chip-removal capacity as well as semi-automatic production is sufficient in the vast majority of cases (Specialized machines such as numerically controlled (NC), computer numerically controlled (CNC), etc. and other advanced production equipment such as flexible machining systems (FMS) should always be considered as a secondary option, that is to say that an attempt must always be made to redesign products and processes so that conventional machines can be used);

b) Very meticulous and precise training for machine operators, setters and assembly workers other than line assembly workers;

c) The technical skills of the setters and fitters must be consistent with the level of technological complexity of the product;

d) Middle-level technical supervisors must receive training of the highest quality, always compatible with the technological level of the products. They will have to play a large part in bearing the technical pressure, comprehending and assimilating know-how in multipurpose enterprises.

e) As far as high-level supervisors are concerned, it should be borne in mind that the purchase of know-how and work under licence reduce the scope of action and the contribution of design departments. This has an immediate effect on the corresponding training.

f) On-the-job training must be provided for the management of multipurpose enterprises, --i.e. it must be more intensive and be given at an earliest stage than in the case of specialized enterprises of the same size. In fact, MPUs must operate with a variety of parts machined by third parties and with assembly activities that almost always correspond, in numerical terms, with those of larger specialized firms. In this case, training is required not only for the procurement manager and the production manager (both with university qualifications) but also for the auxiliary technical staff.

g) As far as production management within the MPUs is concerned, it should be noted that it can develop between two structurally very different extremes. On the one hand, the manufacture of many products or articles (hundreds) consisting of only a few parts and on the other hand the manufacture of 10, 20 or 30 types of machines, each in 2, 3 or 5 different models and each consisting of several hundreds or thousands of parts.

h) In any case, what was formerly very difficult to manage is now radically simpler with the use of micro- and/or minicomputers, and the difficulties and uncertainties of decision-making have to a great extent disappeared. However, this change in the structure of management, which is incidentally not peculiar to the MPUs, calls for specific training.

131. The MPUs raise another problem with regard to the source of licences, the purchase of designs and the requirements for and/or choice of technical assistance. In order to maximize benefits, it is necessary to reduce as far as possible the number of technical standards as well as the variety of raw materials, choosing licences with this in mind. In fact, if absolutely necessary, all these licences can be adopted to a single technical standard, but that takes time and a great deal of technical knowledge, which is often not available.

132. In order that the MPUs be efficient, it is necessary that there should not be too high a difference in level between the technological complexity of the simplest and the most advanced products in the mix. That principle is in

keeping with the MPU 6 already described and compatible with the local technical infrastructure.

133. The multipurpose production approach also raises the questions: "What is the best unit size, what are the minimum and maximum sizes that can be considered as valid, efficient and manageable in the developing countries and above all within the embryonic capital goods industries, i.e. with a labour force of less than 20,000?". Information gathered from the developing countries clearly shows that the size of the unit must be in direct relation with the complexity of the product - it can range from a labour force of 50 to more than 1,000; products of lower complexity can be made with labour forces of less than 100 persons. The basic criteria of size of the MPUs must always be related to correct use of the local technological level and technical infrastructure; and assembly and semi-assembly activities should be avoided.

8.5 The dynamics of multipurpose production

134. Finally, it is necessary to ask the important question: "Can the MPUs guarantee the process of acquisition and mastery of technological knowledge or should they be regarded rather as a passive form of production, at least in the majority of cases?".

135. Initially, the MPUs lead above all to the accumulation of technical knowledge on production, management and repair and maintenance among users. In-house capacity for product design is considerably diminished by the purchase of a large number of licences. The purchase of product knowledge postpones indefinitely the actual assimilation of know-how. This negative aspect can to a large extent be offset by the dynamic role that can be assigned to the MPUs, at least to a wide variety of MPUs and for products of very widely differing technological complexity.

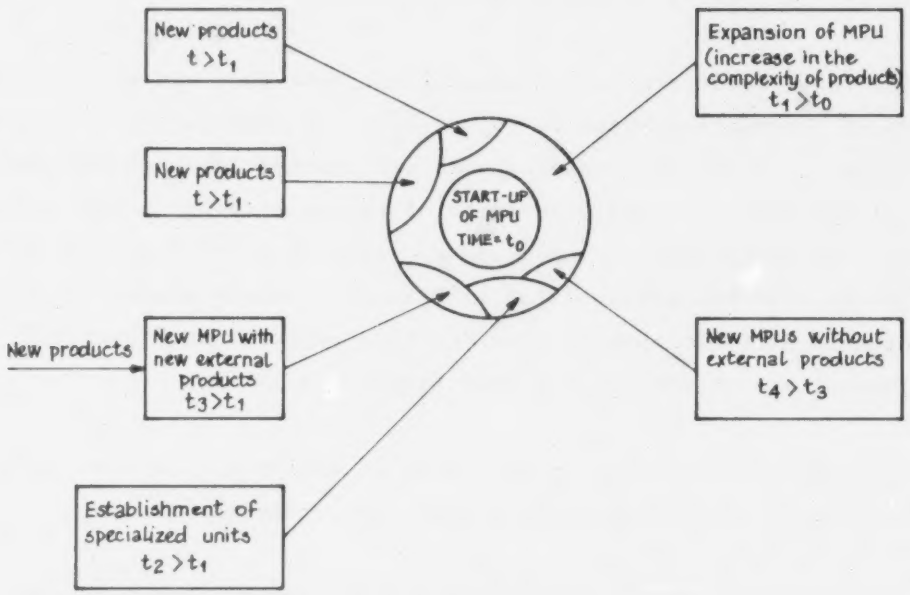
136. On the one hand, the multipurpose plant should be considered as a development pole that in time hands the manufacture of products or lines of products over to new specialized plants. The increase of the market and the technological mastery achieved form the basis for this possibility (see Figure 8.2). On the other hand, it is necessary to offset the transferred

products (releases to specialized units) with an inflow of new products or lines of products, while respecting the composition rules indicated in Figure 8.1. This dynamic process of release and inflow must be achieved, and that is possible with a systematic and progressive increase in the technological complexity of the products manufactured.

137. Under these conditions and to the extent that they can be consistent with the rules of composition shown in Figure 8.1, the MPUs can be transformed into genuine poles of development and as such are irreplaceable in the production context of the capital goods industries of the developing countries. Therefore, the multipurpose production approach must under no circumstances be considered as a static and isolated solution and should always be associated with a dynamic attitude such as that described above (see Figure 8.2) and with a definite pattern of composition (see Figure 8.1).

138. From this point of view, it will then be possible to achieve precise and interesting goals for the developing countries, namely:

- Specific and precise guidelines for the establishment of new multipurpose production activities in existing capital goods industries;
- Precise guidelines to increase the degree of versatility of enterprises that are already operational;
- A correct overview in cases when it is necessary to study and promote a large number of MPUs as part of an industrialization plan;
- Precise guidelines for creation of MPUs which would establish the entry route into the capital goods industry;
- A very thorough approach when it is desired to make diagnoses of multipurpose enterprises and to correct any operational defects.



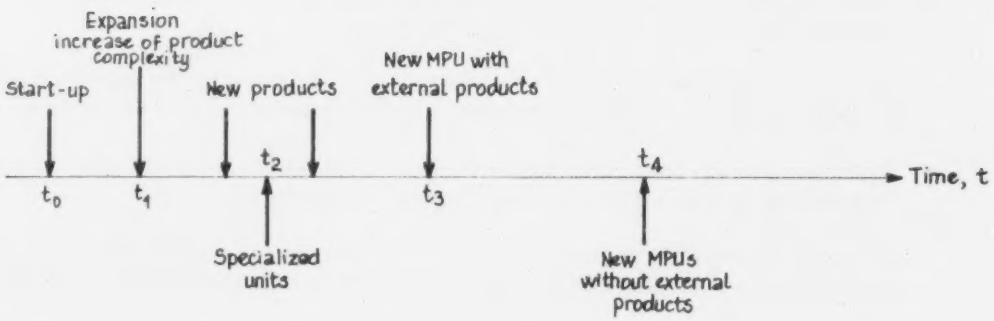


Figure 8.2 The dynamics of multipurpose units

CHAPTER 9

MULTIPURPOSE PRODUCTION OF AGRICULTURAL MACHINERY AND OTHER CAPITAL GOODS FOR RURAL DEVELOPMENT

9.1 Introduction

139. The importance of agricultural machinery and rural equipment in meeting the fundamental needs of Group C countries in general, and Sub-groups C1 and C2 countries in particular, was discussed in Chapters 4 and 7, and elsewhere[48/]. Due to this importance, manufacture of agricultural machinery and rural equipment could be selected as a possible entry route into the capital goods industry in most of these countries.

140. It was shown in Chapter 7 that the developing countries wishing to create and/or to develop their capital goods industries face a variety of obstacles. It was proposed that the multipurpose production approach may help to remove some of these barriers and may make the establishment of production units possible, which could otherwise be postponed indefinitely (see Chapter 8)[49/].

9.2 Demand for agricultural machinery

141. Agricultural machinery, including rural equipment in the broad sense, are utilized in the production of a large number of different crops in circumstances which can significantly vary from country to country or from region to region. In order to meet the requirements of different agricultural and other related rural activities, the spectrum of agricultural machinery covers a very wide range. Furthermore, as indicated in Table 9.1, there are several categories of mobile and stationary machines of different complexity

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48/ - Op. cit. 3/.
- Op. cit. 4/.
- Op. cit. 5/.

a very wide range. Furthermore, as indicated in Table 9.1, there are several categories of mobile and stationary machines of different complexity levels utilized for the same agricultural operation at different degrees of mechanization.

142. In this study, the agricultural machinery is classified into four categories[50]:

a) Hand tools
b) Simple equipment and machinery
c) Tractors and trailed machines
d) Self-propelled machines and complex equipment

This classification is mainly based on the varying degrees of complexity of the manufacture of these machinery and, therefore, the levels of complexity of machine's manufacture and the complexity of its utilization in agriculture are not necessarily correlated.

143. Agricultural machinery is only one of the inputs to agricultural production. Other inputs affecting the agricultural productivity are soil, water resources, fertilizers, pesticides, herbicides, seeds, agricultural technology, labour, etc. The input mix which is utilized in a given country depends on several factors such as availability and characteristics of the arable land, structure of agriculture, rural infrastructure, government policies with regard to agriculture and agricultural mechanization, etc. The discussion here, however, is limited to agricultural machinery only.

144. The major and closely correlated two problems facing many developing countries in general, and Sub-group C1 and C2 countries in particular, are insufficient food production and poverty of rural masses. Therefore, to increase the agricultural output within a rural development concept is one of the goals of these countries. Increasing the output of agriculture is possible through increasing the productivity of existing cultivated areas and opening new land to cultivation wherever possible.

50/ Other classifications are also possible. For example, FAO has adopted the

used: (1) Hand tool technology, [illegible]
(3) Mechanical power technology - FAO; Agricultural mechanization in development: Guidelines for strategy formulation, 1981.

Table 9.1 Main types of agricultural machinery

Agricultural operations		Equipment used by increasing degree of mechanization			
Land development	Clearing and re-cultivation	Simple public works implements Multipurpose hand tools	Brush-clearing and forestry implements and equipment	Scrapers, graders levellers, compactors Forestry-tractors Heavy tractors and gound-breaking equipment	Bulldozers, hydraulic shovels Subsoiling machinery, drain-clearers, drain-cutters, drain-pipelayers
	Ground and soil improvement	Irrigation equipment (valves, mains)		Rotary breaker, ripper, chisel, heavy 4-wheel drive tractor Pumping and water-distribution station	
	Land development, chiefly by irrigation	Simple irrigation machinery and processes: bucket-chains, augers, hand-pumps, etc. Hand tools and supplies for fences		Mobile irrigation equipment Motor pumps Electric fencing (battery)	Self-propelled equipment Permanently installed irrigation equipment
Farming — Crop farming	Soil cultivation	Multipurpose or specialized hand tools	Hand sprayers animal-drawn ridgers, Seeders, fertilizer distributors trailed sprayers	Self-propelled cultivators Tractors and specialized machine Mechanized pickers	Self-propelled machinery reaper-threshers, wine-yard machinery
	Sowing, fertilization, vegetable conditioning				
	Harvesting (horticulture)	Horticultural tools and equipment	Specialized buildings		
Farming — Stock farming	As above	Cultivation and mowing implements	As above Mowers and fodder-handling equipment		
	Chain of foddering operations	Simple multi-purpose buildings	Specialized buildings and equipment	Specialized stock-farming equipment (for non-industrial stock-farming)	For industrial stock-farming (automatic feeders and feed conditioners)
	Other stock-farming operations				
	Transport and handling	Load-carrying devices (baskets, vats, wheel-barrows)	Wagons, carts and other equipment drawn by men or animals Manual discontinuous handling equipment	Low and medium-power multipurpose tractors Multipurpose or specialized trailers Motorized discontinuous handling	Lorries Specialized transport equipment (for milk, meat, grains....) Motorized continuous handling
Post-harvest and other operations	Storage	Storehouses, shelters, sheds, etc.	Buildings with specialized equipment in traditional farming (silos, barns, cribs, etc.)	Industrialized modern buildings	Ditto, but with highly specialized equipment: grain compartments, forage silos, grain augers, silage unloaders, pumps, etc.
	Sorting and packing	Tools	Manual discontinuous sorters and packers	Specialised sorters and packers Batch	Continuous packing equipment (washers, weighers, baggers, etc.
	Conditioning preparation for consumption	Specialized implements (milk-beaters, etc.) for food production	Crop-conditioning equipment (screeners, winnowing machines, shredders, strippers, etc.) Preserving equipment	Apparatus and equipment for particular techniques (sun-drying, dehydration, etc.)	Preserving appliances (refrigeration, boiling, vacuum)
	Transport and handling	See above: "Farming"	See above: "Farming"	See above: "Farming"	Specialized transport equipment for liquid (vats) or solid (crates) food products
	[illegible] waste	[illegible] and windmill power	[illegible] digesters Simple sunlight catchers	Small multi-purpose Power take-off on tractor to operate machines	Electricity generators Continuous digesters Solar panels, etc.

145. To comment on **productivity increase** may be easy but actual implementation is extremely difficult. Introduction of technological changes which are also economically feasible would be necessary but far from being sufficient. The effect of socio-political realities on the success of such efforts could be even greater. However, the discussion of these problems is outside the scope of this study since the purpose here is to discuss the technological issues related to the local manufacture of agricultural machinery in developing countries.

146. One way to express agricultural productivity is to measure it in terms of equivalent metric tons of cereals per hectare harvested. Figure 9.1 shows the yields achieved in different groups of countries and regions. Comparison of the low yields of developing countries and their levels of utilization of inputs[51/] reveals that one of the main causes of low productivity is insufficient use or unavailability of inputs, and among them agricultural machinery.

147. Once the need for agricultural machinery is established, two further questions should be raised: "For which types of agricultural machinery does the demand exist or can be created?" and "How can these machinery be domestically produced?". The answer to the first question, some aspects of which are discussed in the rest of this section, depends on a multitude of factors[52/]; such as the structure of agriculture, agricultural mechanization strategies, socio-political objectives, etc. The second question, on the other hand, is the subject matter of next sections.

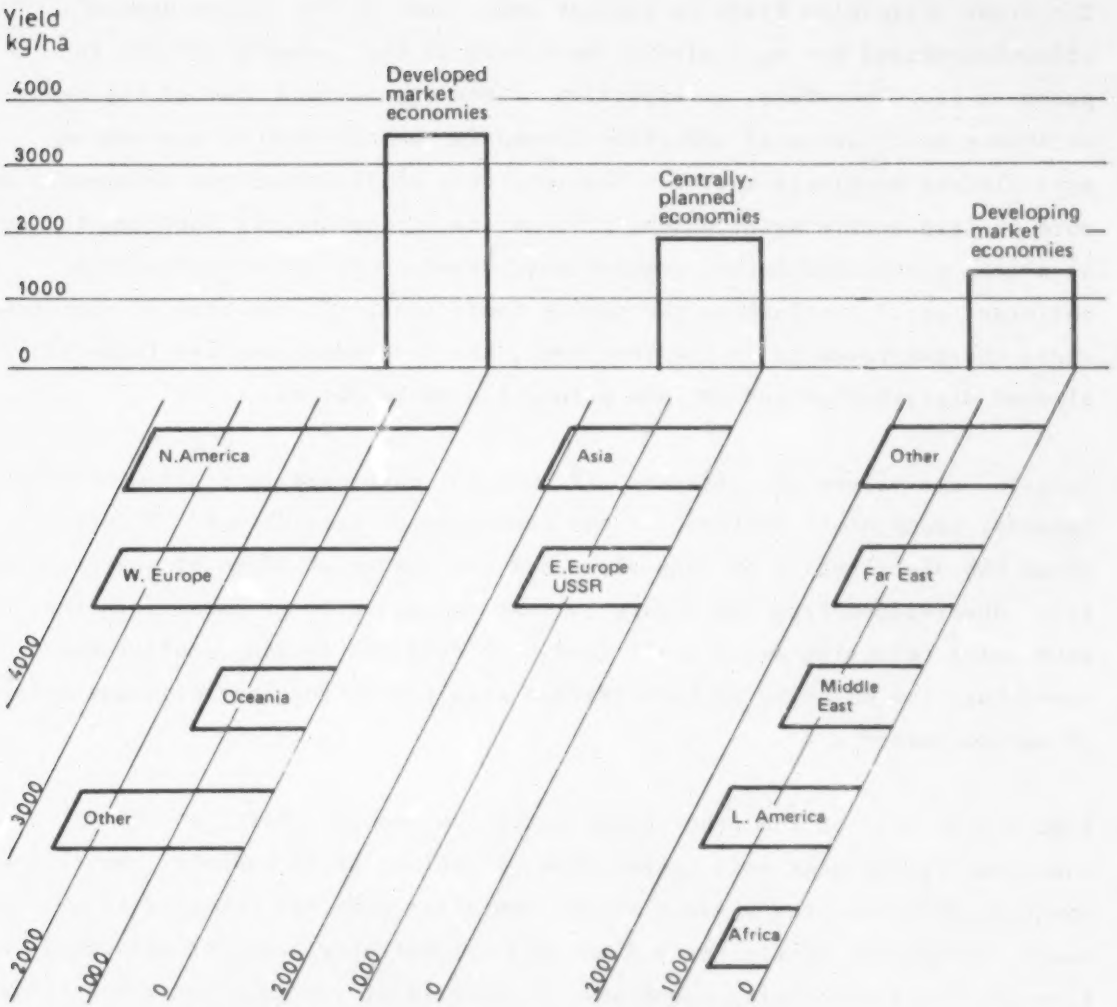
148. In estimating the demand for a product, either one of the following two definitions can be the starting point:

a) The exchange-value of the product which identifies the product as a commodity and pre-supposes market exchange relations.

b) The use-value of the product which is assigned to it not for its possible exchange, but for its usefulness to the user directly.

51/ UNIDO; The agricultural machinery industry in the 1980s: Factors for international co-operation, ID/WG.400/1, 1983.

52/ ibid.



Source: (1) FAO; Trade yearbook, vol. 34, 1980.
(2) UNCTC; Transnational corporations in the agricultural machinery and equipment industry, ST/CTC/24, 1982.

Figure 9.1 Cereal yields of different groups of countries

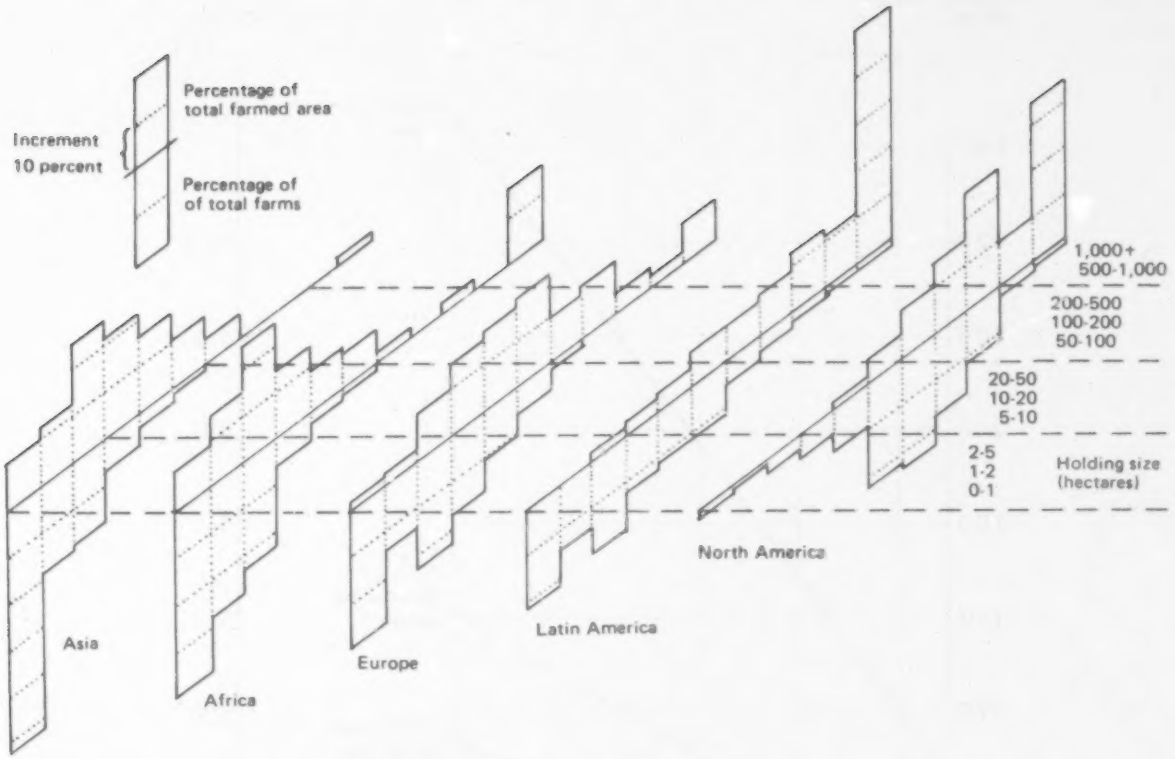
The first definition leads to another one; that of "effective demand". The effective demand for agricultural machinery is the farmer's ability to purchase it. Therefore, irrespective of the urgency and size of the need, the existence or creation of effective demand is the only way to open up an agricultural machinery market. However, this still leaves the Government as a more or less active agent which, through its various policy instruments (such as price, credit and import regulations, development of infrastructure policies, etc.), influences the market conditions. In the case of societies where the use-value is in the forefront, the Government has the tasks of planned distribution and optimum allocation of resources.

149. The use-values of different agricultural machinery in a given country depends, among other factors, on the structure of agriculture. Figure 9.2 shows the distribution of farm sizes and the number of farms by region. The first observation from the figure is that the majority of farmers in the developing countries own a small land. In Asia and Africa, small farms constitute the majority of total farmed area indicating the intensive nature of agriculture[53/].

150. Figure 9.3, on the other hand, gives the tractor energy and time requirements for some soil preparation operations as an example. Recalling the fact that expected minimum annual operation time for tractors is 1000-1200 hours, comparison of Figures 9.2 and 9.3 demonstrates that for the small farmers in the developing countries, tractor is of use only for a very limited period of time anually, so it is not viable unless its shared utilization is arranged. A similar viability analysis can be made for other agricultural machinery.

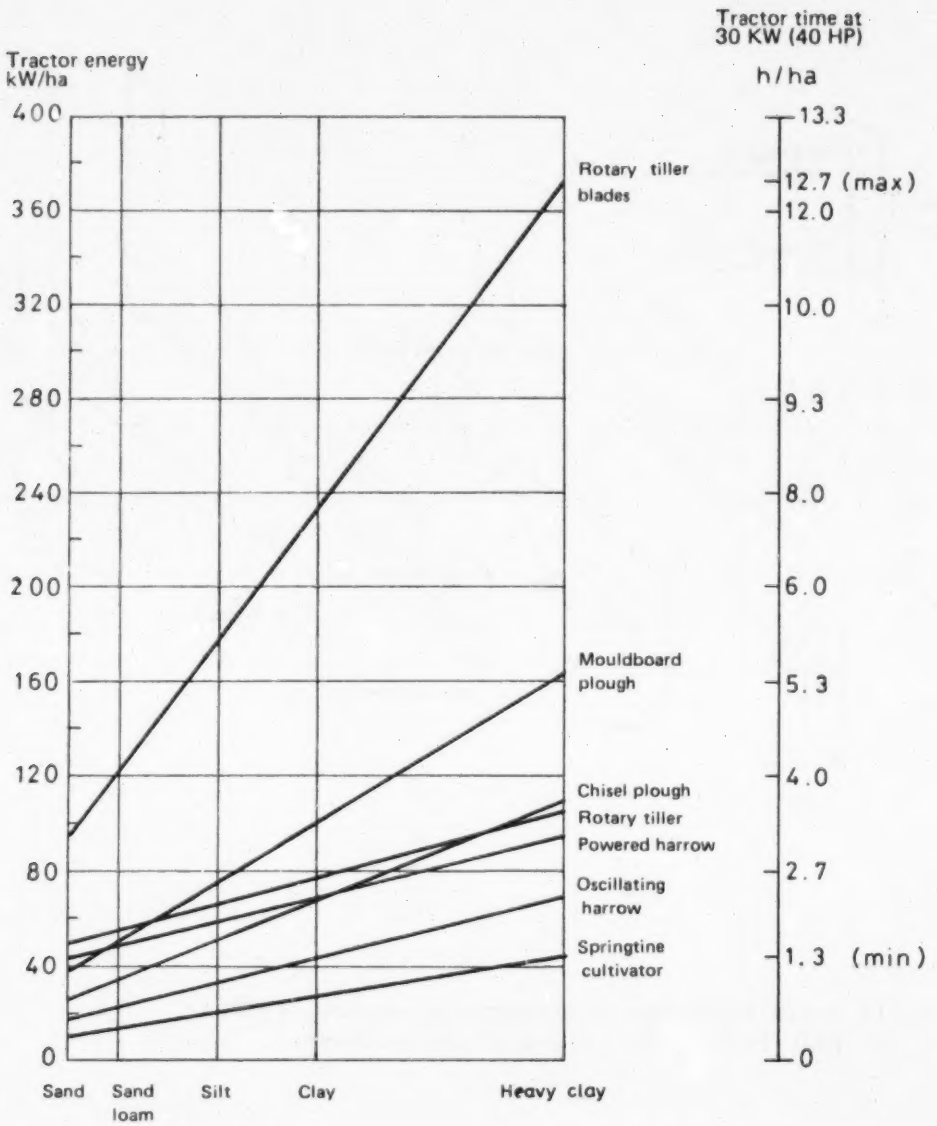
151. When the market conditions prevail and the governmental incentives are absent, farmers' ability to accumulate capital is the only source of creating demand for agricultural machinery. The purchasing power of farmer depends, among other things, on the size of cultivated area, the types of crop and yield per hectare. Table 9.2 compares the average farm size, yield, production and years required to pay a tractor in developed and developing countries and shows the very low level of purchasing power of small farmers in the developing countries.

53/ Op. cit. 51/.



Source: (1) World Bank; World development report, 1982.
(2) FAO; 1970 world census of agriculture.

Figure 9.2 Comparative distribution of farmed area



Source: Perdok, U. D. and van de Werken, G.; Power and labour requirements in soil tillage, in "Agricultural mechanization in the tropical and developing countries", International Congress of the 12th Agricultural Machinery Exibition, 1982.

Figure 9.3 Tractor energy requirements

Table 9.2: Tractor affordability (1979 figures)

	Average farm size, ha	Cereals yield kg/ha	Production[a/] metric tonnes	Years to pay tractor[b/]
Small farms				
Developed market economy	2.1	3,470	7.3	3.0
Developing market economy	1.4	1,423	2.0	15.0
Medium farms				
Developed market economy	19.2	3,470	66.6	0.3
Developing market economy	9.2	1,423	13.1	2.3
Large farms				
Developed market economy	142.4	3,470	494.1	0.08
Developing market economy	86.9	1,423	923.6	0.50

Source: (1) UNCTC; Transnational corporations in the agricultural machinery and equipment industry, ST/CTC/24, 1982.
(2) FAO; Trade yearbook, vol. 34, 1980.

a/ Assuming double cropping in small and medium farms and single cropping in large farms.

b/ Average 1979 price of tractor expressed in metric tonnes of cereals is taken as 40 tonnes in developed market economies and 60 tonnes in developing market economies.

152. The analysis presented here and in the other UNIDO documents[54,55/] show that although there is a huge need in developing countries for all types of agricultural machinery, the demand is low. This situation is generally caused by the limited purchasing power of the small farmers which could only create a market for low-cost simple machinery. However, the demand for agricultural machinery can be increased through the intervention of state. This intervention can be summarized at macro-economic level as efforts to increase the investment ratio of agriculture[56/]. According to a UNIDO study, the average investment ratios of a sample of forty countries over the period 1965-1975 vary between less than 5% and approximately 25%; the developed

54/ Op. cit. 51/.

55/ UNIDO; The world agricultural machinery industry: Prospects for international co-operation, ID/WG.400/3, 1983.

56/ Agricultural investment ratio of a country is defined as "total annual agricultural investment/total annual agricultural production". Expenditure on agricultural mechanization generally forms the major part of the agricultural investment - UNIDO; World-wide study on the agricultural machinery industry, UNIDO/ICIS.119, 1979.

countries being at the higher end and the least developed ones being at the lower end[57,58/]. For developing countries, increasing the agricultural investment ratio, generally, necessitates the transfer of international and/or other national financial resources to the agricultural sector.

153. Although the wide product range of agricultural machinery, from simple hand tools to very complex machines, creates many possibilities for local production, the present level of production of agricultural machinery in the developing countries is far from being sufficient. Therefore, the rapid increase of local production of agricultural machinery in general and low-cost machinery and equipment in particular is required in order to meet the demand of small farmers.

9.3 Multipurpose production of agricultural machinery

154. It is clear that the problems of agricultural machinery production should be discussed within the framework of agricultural, agricultural mechanization and industrial strategies of a given country. However, this wider discussion is beyond the scope of this paper. The aim here is to identify the possibilities of an integrated approach to couple the agricultural machinery and capital goods industries in order to achieve better utilization of the scarce resources of a developing country.

155. In Chapter 3 and 8, it was demonstrated that the similarity of technological production routes of agricultural machinery and some other capital goods makes it possible to manufacture both product groups in the same multipurpose production unit provided that the rules of multipurpose operation are observed.

57/ An agricultural investment ratio of 25% for a mainly agricultural country with 40-50% of its GDP being contributed by agriculture will mean 10-12.5% of its GDP being invested in agriculture.

58/ It may be interesting to compare the agricultural investment and military expenditure to see that the latter being higher for some developing countries (For military expenditures see: Väyrynen, R.; Industrialization, economic development and the world military order, in "UNIDO; Industrialization strategies and country case studies", vol. 6, p.409-508, IOD.337/Rev.1, 1980).

156. For the purpose of this study, production units of agricultural machinery according to their utilization of different technological production routes are classified as the following:

- Village backsmiths
- Rural workshops
- Small-scale industries
- Medium-scale enterprises
- Large-scale enterprises

It should be stated from the outset that production units of different levels should not be thought of as being mutually exclusive. On the contrary, they should co-exist and complement each other.

9.3.1 Rural development programmes and rural industries

157. Agriculture, food production, rural infrastructure and rural development as a whole are at the focus of growing political attention of both national decision-makers of the developing countries and the major aid, financing and co-operation organizations[59,60,61,62,63]. In this connection, many developing country governments have declared policies to encourage establishment and to support industry in rural areas. However, only few countries have actually implemented such policy measures [64].

158. Development of rural industries could carry important implications for agricultural mechanization. They also create non-farm rural employment and

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59/ Canadian Hunger Foundation and Brace Research Institute; A handbook on appropriate technology, Ottawa, 1976.
60/ Op. cit. 5/.
61/ Müller, J.; Liquidation or consolidation of indigenous technology, Aalborg University Press, Denmark, 1980.
62/ UNIDO; Appropriate industrial technology for light industries and rural workshops, ID/232/11, 1980.
63/ World Bank; World development report 1982, Oxford University Press, New York, 1982.
64/ Op. cit. 50/.

help to stabilize and even expand farm employment. The prospects of increasing the level of knowledge and mechanical skills of rural population can also be opened through the development of rural industries. However, in many cases, the socio-political feasibility and the economic and technological feasibilities of rural industrialization programmes do not simultaneously exist. Examples from developing countries suggest that, in such cases, the government objectives and decisions would be the determining factors.

159. Traditional **village blacksmiths** were the exclusive manufacturers of agricultural hand tools and simple rural equipment. Today, they continue their activities and manufacture hand tools (hoes, machettes, knives), simple machines (swing ploughs, harrows), simple rural equipment (yokes, carts), as well as household equipment (ovens, pans, etc.) and miscellaneous items (doors, locks, chains). They also produce spare parts for simple agricultural machinery, in particular for the animal-drawn equipment, and attend to their repair and maintenance.

160. Blacksmiths' production tools are generally made by themselves and they utilize scrap iron and locally available wood and charcoal as raw materials. In most of the cases, the necessity of subsistance farming makes their production activities a part-time job. Except in rare cases, they have a traditional training only. The possibilities of improvement of production tools, techniques and hence the quality of products are quite limited.

161. Centralized mass production or importation of quality hand tools and marketing of them in villages is one of the reasons why blacksmiths are compelled to decrease their activities. The penetration of tools from organized industry increases as the economic rural infrastructure develops and the access to remote villages becomes easier.

162. Programmes aimed at introduction of animal-drawn implements have demonstrated that repair and maintenance services which can be provided by the village blacksmiths are vital for the success. There are several governmental level measures which can be taken to secure the market for blacksmiths and to assist them developing their activities. Reservation of the lower end of animal-drawn implements' market to blacksmiths has been successful in India.

Formation and assisting artisan groups and co-operatives have been utilized in Benin (Cobemag project), Niger (Darma/APR project), Tanzania (Utundu project), etc. Similarly, oxenization programmes in Northern Ivory Coast, CDMT in Mali, Ardu and Bako projects in Ethiopia and the Nord Togo operation have employed or assisted artisan-blacksmiths within the framework of agricultural development schemes. Within these programmes, blacksmiths have been given training, supplied with subsidized and better production tools, and subcontracted to produce simple machines or parts.

163. Village blacksmiths, with their dual function as farmer-artisan and with their close proximity to users, could understand the local conditions better than anybody else and hence manufacture the suitable tools. They are vertically-integrated[65/] and diversified in their products. However, problems such as inefficient supply system, financial restrictions, seasonal markets, insufficient training, poor product quality and competition from urban industry and imports limit the development of village blacksmiths.

164. The promotion of village industries requires government intervention. However, the requirements for planning, monitoring and supporting viable blacksmith operations are in many cases under-estimated. After a short initial impact, it is common for the results to be disappointing and hence the governments are tempted either to intervene with excessive subsidies regardless of economic viability or to abandon the project completely.

165. Operational examples from developing countries demonstrate that there is considerable scope for production of some agricultural machinery, rural equipment and other capital goods in decentralized small-scale rural workshops. Commune and brigade level maintenance and machinery production workshops in China, several projects in Africa (Cobemag in Benin, Arcoma Corema in Upper Volta, Rural Craft Workshops -RCWs in Tanzania, etc.) are some of the examples.

65/ Up to quite recent times, blacksmiths were smelting their iron themselves. --op. cit. 61/.

166. Ideally, rural workshops could operate within a network consisting of a number of decentralized workshops and a central production unit. Depending upon their development level, the rural workshops can perform the finishing and assembly of manufacturing kits of semi-finished machines distributed by the central unit; and/or they can be subcontracted by the central unit to manufacture finished and semi-finished parts; and/or they can carry-out the complete manufacture of some machines. Repair and maintenance of all these machinery could also be carried-out by the rural workshops.

167. Several villages within the reach would constitute the immediate market for rural workshops. The size and location of the market could considerably change when rural workshops operate within a network of agricultural development project. Preferential government purchases and import controls would help to stabilize and expand the rural workshops' market. Availability of loans to farmers when purchasing agricultural machinery produced by rural workshops would be the most effective support for the workshops.

168. The types of products that can be manufactured and the services that can be rendered by the rural workshops depend, among others, upon the technological level of the workshop, the development stage of rural infrastructure (particularly availability of electricity, roads and transport) and effectiveness of the organizational set up. The discussion here is limited to the investigation of technological possibilities for rural workshops to manufacture agricultural machinery, rural equipment and other capital goods for rural use.

169. Table 9.3 gives the summary of technological production routes of different levels of rural workshops. As seen from the table, the possible product mix of rural workshops could cover agricultural machinery (hand tools, animal drawn equipment, irrigation, silage and transport equipment) and other capital goods (building construction equipment, food processing machinery, etc.) and some consumer durables for rural use. This product diversification indicates the multi-purpose nature of the rural workshops and their possible impact on the rural development. The capital goods produced by the workshops could also promote other rural industries.

Table 9.3: Identification of the types of rural workshop

Level of the workshop	Manufacturing processes					
	Forging	Sheet, tube and profile working	Welding	Machining	Assembly	Testing
M (without electricity)	-Manual forging with anvil and hammer	-Cutting with snips, hand hacksaw, hand torch, lever shear -hand bending -manual 3-roller rolling	-Torch welding (gas)	-Manual tapping and threading of pipes -Filing (files, vices)	-Simple manual assembly with hand tools -Brush painting	-Geometric measurements only
E1 (with electricity)	--	-Cutting with reciprocating saw, manual lever shear -Hand bending -Manual 3-roller rolling	-Electric arc welding	-Drilling -Disc grinding -Manual tapping and threading	-Manual (with also bolts, nuts & rivets) -Spray painting (without compressor)	-Inspection -Geometric measurements
E2 (with electricity)	--	Same as E1 plus -Guillotine shear -Bending press	Same as E1	Same as E1 plus -Universal lathe turning	Same as E1	Same as E1

170. The rural workshop as a multipurpose production unit is mainly a mixture of types MPU1, MPU2 and MPU8 (see Chapter 8). The process technology of the rural workshops comes with their production machinery. The general purpose nature of this equipment provides flexibility and product diversification within the same technological complexity level. Minimum knowledge required is the operator skills for machinery and the artisanal skills for manual operations. Upgrading the existing skills of the workshop operators would necessitate training programmes and improvement of manufacturing processes through introduction of jigs and fixtures[66/].

171. One of the major problems of the rural workshops would be the lack of product design capabilities. Therefore, it would be necessary to provide rural workshops with proven designs, prototypes and manufacturing process files of equipment which are adapted not only to local agricultural conditions but also to their technological capabilities[67/]. This requires an organizational framework and involvement of national, regional and international design centres and international co-operation agencies. In cases where the national design capabilities do not exist or are weak, regional and international co-operation become vital.

172. There is also scope for international co-operation for the supply of production equipment and raw materials to rural workshops. In this regard, bilateral and multilateral co-operation programmes could be very effective[68/].

173. As stated before, promotion of rural industries requires government policies and long-term commitments. It is not an easy task. The programmes could necessitate heavy subsidies especially when the socio-political aspects are given more emphasis than the economic and technological ones. Furthermore, examples have demonstrated that[69/] an essential factor affecting the success of rural production units is the actual ownership of the rural people.

66/ Op. cit. 4/.
67/ A by-product of the distribution of product designs would be standardization.
68/ E.g. supply of steel products to Mali through a Swedish aid programme.
69/ Neighbourhood workshops in China, Saemaul factories in Republic of Korea, etc. --UNESCAP; Small industry bulletin for Asia and Pacific, No. 17, 1981.

9.3.2 Small-scale industries

174. Development of urban and sub-urban small-scale industries is discussed in detail elsewhere[70/]. The consideration here will be given to the possibilities of participation of the small-scale industries in the manufacture of agricultural machinery and other capital goods. The observations are based on several case studies which were carried-out by UNIDO.

175. Traditional small-scale firms are comprised of a few dozens workers at the most whose activities relate to outlets in the urban sector rather than those in the rural sector. Boilerworks and automobile repair, maintenance and spare parts manufacture are the most common examples of such activities. These units are generally accommodated in an industrial park or small crafts complex where the utilities (electricity, water, etc.) are made available. Such complexes are usually located in urban or suburban areas providing access to markets and raw material supplies.

176. Small-scale firms are almost always privately owned (individual, partnership or co-operative). The main investment source is generally the private savings and private entrepreneurship plays a very important role in establishing and operating the small-scale industries.

177. The manufacturing process technology of small-scale industries is generally embedded in the production equipment. Product technology, on the other hand, depends on copying and adapting imported designs. Diffusion of local product design technology takes place through imitations of successful designs.

178. The production equipment and manufacturing processes of small-scale firms are similar to E1 and E2 type rural workshops (probably with additional machine tools for welding, grinding, etc., and machine presses). One interesting feature of small-scale production, however, is the varying degrees of vertical integration depending upon the spatial distribution of manufacturing units. When they are accommodated in an industrial complex or organizationally integrated in co-operatives, a high degree of division of

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70/ A complete bibliographic index and abstracts of UNIDO publications on the subject can be retrieved from UNIDO/INTIB.

labour and horizontal integration build-up[71,72/]. The firms prefer to specialize in one or two manufacturing processes (machining, welding, forging, casting, etc.) and utilize other neighbours as subcontractors according to the type of the product on order.Although this route brings some production contr l and standardization problems, it helps to limit investment costs of individual firms and improves the capacity utilization through diversification. The owner-manager's problems could also be reduced when he deals with those processes for which he has the knowledge and/or skills.

179. Multipurposeness is also encouraged when local medium- and large-scale enterprises support the small-scale industries. The commercial form of this support is sub-contracting (both processing and manufacturing parts and components) but it can also have a technological component. The technological know-how and the demand for quality and standardization of the larger firm could help the smaller one to upgrade his products and processes. The only disadvantage appears when small-scale firms lose their flexibility and become satellites of the larger ones, i.e. fully committing their operations to sub-contracting. In such cases, small firms lose contact with their traditional markets and depend totally on the demand for large-scale enterprises' products.

180. Semi-centralized and flexible nature of the small-scale industries enable them to manufacture a wide range of agricultural machinery (from hand-tools to power tillers), rural equipment (pumps, small diesel engines, sprayers, transport equipment, carts, trailers, water tankers, etc.) and other capital goods and engineering industry products of similar technological complexity level (equipment for building construction - brick presses, concrete mixtures, steel structures; food processing equipment - animal breeding equipment, oil presses, milk processors, etc.; almost all types of light boilerworks; spare parts and components for the above and other equipment).

181. Many developing countries do not have the capacity for manufacturing

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71/ Op. cit. 62/.
72/ Baldo and Co. (UNIDO consultants); The status of the agro-mechanization and of the relevant industry in Syria and identification of training needs, 1983.

capital goods or only have embryonic capacities for this. By contrast, almost all of them need a progressively mechanized agricultural system. The production of agricultural machinery constitutes, under these conditions, an interesting way of entry into the capital goods industry. Provided that it is planned, encouraged and supported by government policies, there would be no insurmountable technological obstacles to establish multi-purpose production units to manufacture primarily agricultural machinery and progressively other capital goods through diversification. Small-scale industries are well-suited for this purpose.

9.3.3 Multipurpose medium-scale production

182. Manufacture of agricultural machines of technological complexity levelsÑII and III necessitates the utilization of different manufacturing processes, technological know-how, skills, semi-finished products, technical services and components (see Figure 3.2, Table 3.1). Each of these industrial operations has a minimum size to be technologically and/or economically feasible[73/]. Therefore, the medium-scale plant, whether it is a specialized unit concentrating on a limited number of processes (e.g. casting or forging or heat treatment only or manufacture of parts and components) or a vertically-integrated unit producing the inputs of its final product, has to reach a "critical" size[74/].

183. The capacities which have to be created in order to reach the required critical sizes would seldom be viable when the limited and seasonly variable market (even that of a large developing country) for agricultural machinery is considered[75,76/]. One possible solution is the utilization of multipurpose

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73/ For example, if broaching is required as one of the machining processes, technologically minimum size would be one conventional broaching machine which can accommodate the piece of work to be machined and perform broaching according to required specifications. A level II foundry (e.g. with wood pattern moulding) would require, in addition to blast cupola smelting casting process, a pattern making workshop and cleaning processes. In order to be able to economically operate the casting and other ancillary processes a minimum capacity has to be reached --UNIDO; Metal production development units, UNIDO/IOD.368, 1980.

74/ Op. cit. 15/.

75/ Villela, A.V. (UNIDO Consultant); Brazilian agricultural machinery industry, 1983.

76/ Turkish Industrial Development Bank; Survey of Turkish agricultural machinery producers, 1983.

approach. The analysis of technological production routes of agricultural machinery and other capital goods has demonstrated that it is technologically possible to accommodate the manufacture of agricultural machinery and other capital goods within the same multipurpose production unit (MPU) --see Chapters 3 and 8.

184. Multipurpose operation, however, is not without problems even when the precautions discussed in Chapter 8 are taken. First, it brings additional pressure on management of the medium-scale firm; wider market relations, after sales services, etc., have to be organized and production planning and control become more critical. Then, product design and development should also be diversified and become responsive to the market demand. Furthermore, constant attention should be paid to the on-the-job training of production workers.

185. One of the most complicated problems of MPU is the planning and design of plants with built-in diversification possibilities. Even if the demand for agricultural machinery could be accurately estimated, the market for other capital goods could have irregularities and uncertainities. This situation could be improved by the intervention of Government: The Government could show its determination to protect the domestic agricultural machinery and other capital goods industries from foreign competition by issuing import restrictions and/or tariff barriers as soon as any one of these goods is locally produced. Further, as one of the main purchasers of capital goods for public works, building construction, rural development programmes, etc., the government could secure a sizable market for the local manufacturers[77/].

186. It is to be noted that multipurpose approach can be considered not only for the newly established plants but also for the existing production

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77/ This is also important to partially meet the need for excessively high working capital in developing countries through down-payments for government orders. The need for high working capital may be explained by slow annual turnover of inventories, excessive stocks of imported parts and components because of irregularities in importation, etc. --World Bank; Fostering the capital goods sector in LDCs: A survey of evidence and requirements, Staff Working Paper No. 376, 1980.

capacities. Analysis of the existing facilities and their subsequent upgrading could create diversification possibilities and lead to better capacity utilization. In this connection an interesting example could be the captive repair and maintenance workshops attached to the existing large-scale plants or systems (railroads, sugar factories, iron and steel works, mining complexes, etc.). In general, they are diversified to some extent in order to be able to attend to a wide range of repair and maintenance requirements and,therefore, a modest investment to modify, upgrade and re-organize could be sufficient to start the manufacture of agricultural machinery and other capital goods.

187. Proper selection of general purpose production machines and processes and suitable lay-out from the outset would help later to ease some of the difficulties of diversification. Technology selection and possible transfer should also be according to the requirements of multipurpose operation (see Chapter 8), i.e. more attention should be paid to the mastery of processes rather than concentrating on the product design.

188. Multipurpose medium-scale industries with a diversified product line may find it difficult to have access to the international technology market. The size of their operations and/or their product mix may not be of interest to large-scale technology sellers from developed countries. However, there are other possibilities: Co-operation with small- and medium-scale enterprises (SMEs) from developed countries and/or co-operation with other developing countries which have alreadey mastered the required technologies.

189. At present, most of the SMEs in developed countries are suffering from the present stagnation of their traditional markets for agricultural machinery. Therefore, they are paying more attention to the possibilities of penetration into the markets of developing countries. Although their primary target is the exportation of complete equipment, they could also consider the transfer of technology arrangements. In fact, there are several examples (both successes and failures) of joint ventures and licensing arrangements between similarly sized companies from developed and developing countries. The technologies involved have been generally for the manufacture of equipment, parts and components. Commercial and legal aspects of arrangements have been similar to those prevailing in international markets and commonly applied by larger firms.

190. SME in a developed country is a dynamic entity which is able to respond to ever-increasing quality and complexity requirements of the home markets. Rapid changes bring short product cycles and result in depreciating technologies in short periods. This, however, could become an advantage for SME in its dealings with the medium-scale industry in a developing country. Since the latter's need would not always call for the state-of-the-art technologies, SME could enter into the arrangement with a fully depreciated technology and could increase its profitability.

191. Although SMEs are generally interested in industrial co-operation with developing countries, their actual involvement has been limited. This could be attributed to the existence of, among others, two major barriers: The lack of dialogue between prospective partners and inability and/or unwillingness of SMEs to take financial risks in unknown markets. At the first look, it may seem that both barriers have been erected by the lack of information but further analysis would indicate that there are other factors affecting the chances of co-operation.

192. In order to start a dialogue, first the partners should be identified, then the demand of the developing country and the capabilities of SME should be made transparent. The examples have demonstrated that a dialogue could start quite easily when the developing country firm is a trading partner of the SME, distributing and/or servicing its products. In such cases, SME would have sufficient information on the prevailing local conditions and market prospects. In another set of examples, SMEs have been encouraged by the TNCs operating in the developing countries. In particular, TNC subsidiaries and joint ventures, under the pressure of developing country governments to increase local integration, would promote the manufacture of parts and components by local firms which would purchase the technology from the same SME supplying TNC's home operations.

193. In other cases, however, neither of the abovementioned possibilities to identify partners nor to establish a dialogue exist. Then, identification of the demand becomes even more important. National policy-makers should select the priority products that could be locally produced. They should also announce their market manupulation policies (incentives, customs regulations,

etc.). If transparency could be brought to demand and market conditions then it would be possible for SMEs to calculate profit prospects and associated risks.

194. Considering the lack of international experience of newly established medium-scale firms in the developing countries and the concentration of marketing operations of SMEs in the developed countries, it seems necessary to establish national and international frameworks and/or to increase the utilization of existing ones in order to promote and support the co-operation between such partners[78/].

195. Research and development activity is an important element of operation of medium-scale industry. The adoptation of products and processes and new product designs would increase the flexibility, decrease the response time to market changes and widen the product range. Yet, the experience from developing countries has shown that, due to different reasons (but mainly due to the cost of R+D) such activities have been limited to ad-hoc innovative adoptation work. The contributions of national and regional design centres and universities have, except in some cases, been also limited because of weak or non-existing links between these institutions and industry.

196. In addition to encouraging industry level research and development work by incentives, there is scope for stronger national action to strengthen the links between national research and development institutions and industry. Co-operation with the regional design centres should also be re-inforced and a framework should be established so that the real and practical problems of industry could be reflected to regional centres.

197. UNIDO and other international organizations could play an effective role in collecting and disseminating data on completed and on-going research and development work.

78/ There is already some effort along this line: International co-operation agencies (such as UNIDO), intergovernmental organizations (EEC, Commonwealth Secretariat, etc.), national and international manufacturers' and other professional associations are trying to fill the information gap.

9.4 Conclusions

198. Development of the agricultural machinery industry in developing countries necessitates, first of all, the analysis of agricultural system. Then the suitable mechanization should be decided upon according to the structure of agriculture and with due consideration to the socio-political, economic and technological criteria selected by each Government.

199. At this point, it is very important to make the distinction between "need" and "demand" for agricultural machinery. Need could be huge but it is the demand or affordability which should be the basis for industrial decisions. Therefore, the types of agricultural machinery for local production should be selected from those for which demand exists or can be created.

200. The first step towards increasing the domestic production of agricultural machinery should be the full utilization and upgrading of existing skills and facilities. For this purpose, village blacksmiths, rural workshops, small-scale industries as well as medium- and large-scale manufacturers of agricultural machinery and other capital goods should be considered.

201. Comparative analysis of raw material inputs, intermediate manufactured inputs, manufacturing processes and required skills and know-how of agricultural machinery and other capital goods industries indicates that there are similarities and linkages between them which create multipurpose production possibilities at any stage of the development (see Chapters 3, 4 and 8). Therefore, a better utilization of a given amount of resources in a developing country could be achieved through an integrated approach coupling these two sectors.

202. When the capital goods industry (including basic facilities for casting, forging, etc.) exists, then the diversification of the existing units and/or establishment of new MPUs to produce agricultural machinery which are technologically compatible to the development stage of the capital goods industry is always possible. In fact, this type of diversification and creation of new capacities are being observed in many developing countries.

203. This study argues that when the industrial infrastructure is not sufficiently developed and the capital goods sector is weak, there is a possibility to adopt an industrial strategy for the development of agricultural machinery manufacture before creating capacities for the production of other capital goods. It is also demonstrated that multipurpose operation of agricultural machinery industry to produce other capital goods is technologically possible for all developing countries of different levels of development.

204. Within the framework of integrated manufacture of agricultural machinery and other capital goods, there is scope for international co-operation at all levels of development. In this chapter, particular emphasis is given to the possibility of increased involvement of small- and medium-scale enterprises (SMEs) from developed countries in co-operating with counterparts from developing countries. It is argued that SMEs are in a better position to meet the technology needs of medium-scale industries in developing countries.